

**ADB TA 6357: Central Asian Countries Initiative for Land Management Multi-country
Support Project**

CACILM Multi-country Partnership Framework

Support Project on Sustainable Land Management Research

Sustainable Land Management Research Project 2007-2009

Final Report

Part II - DRAFT

Central Asian Countries' Research Reports



**Regional Office of ICARDA for Central Asia and the Caucasus (CAC),
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Abbreviations

ADB	Asian Development Bank
Asl	Above sea level
ARD	Agricultural Research for Development
ARP4	Fourth Assessment Report of the Intergovernmental Panel on Climate Change
ARI	Advanced Research Institute
AVRDC	The World Vegetable Center
CAC	Central Asia and the Caucasus
CACAARI	Central Asia and the Caucasus Association of Agricultural Research Institutions
CACILM	Central Asian Countries' Initiative for Land Management
CATCN-PGR	Central Asian and Trans-Caucasian Network for Plant Genetic Resources
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)
CIESIN	Center for International Earth Science Information Network
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
CIP	Centro Internacional de la Papa (International Potato Center)
CP	Challenge Program
CSO	Civil Society Organization
ctn	Centners (common agricultural unit; 10 centner = 1 t)
CWANA	Central and Western Asia and North Africa
DSR	Direct Seeding of Rice
EM	Electromagnetic
FAO	Food and Agriculture Organization of the United Nations
FESLM	Framework for Evaluating Sustainable Land Management
FTI	Faculty Training Institute
FDEM	Frequency Domain Electromagnetic
GEF	Global Environmental Facility
GHG	Greenhouse gas
GIS/RS	Geographic Information System and Remote Sensing
GFAR	Global Forum for Agricultural Research
GLP	Good Laboratory Practice
GNI	Gross National Income
GPR	Ground penetrating radar
HQ	headquarters
ICARDA	International Center for Agricultural Research in the Dry Areas
ICBA	International Center for Biosaline Agriculture
ICM	Integrated Crop Management
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICRAF	The International Centre for Research in Agroforestry
IIWG	Intercessional Intergovernmental Working Group

Abbreviations

IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
ICWC	Inter-State Commission for Water Coordination
IMPACT	International Model for Policy Analysis of Commodities and Trade
IPCC	Intergovernmental Panel for Climate Change
IPGRI	The International Plant Genetic Resources Institute
IPM	Integrated Pest Management
IPTRID	International Program for Technology and Research in Irrigation and Drainage
IRRI	International Rice Research Institute
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
KRII	Kyrgyz Research Institute for Irrigation
MAWMPK	Ministry of Agriculture and Water Management and Processing Industry of Kyrgyzstan
MDG	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
Mha	Million hectares
MRWF	Medium Range Weather Forecast
MSEC	Multi-Country Secretariat
MTP	Medium Term Plan
NARS	National Agricultural Research System
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organization
NIDFF	National Institute of Deserts, Flora and Fauna, Turkmenistan
NRM	Natural Resource Management
NSRDRI	Natural Resources and Sustainable Development Research Institute, Kazakhstan
NSEC	National Secretariat
PFU	Program Facilitation Unit
PMI	Policies, Markets and Institutions
PGRFA	Plant Genetic Resources for Food and Agriculture
PRIAA	Pri-Aral Research Institute of Agroecology and Agriculture, Kazakhstan
PSC	Program Steering Committee
PSR	Production System Research
RCT	Resource Conserving Technology
R&D	Research and Development
RI	Research Institute
RNA	Research Needs Assessment
RS	Reflectance Spectroscopy
SANIIRI	Central Asian Scientific Research Institute for Irrigation
SASRI	Soil and Agrochemistry Science Research Institute, Kazakhstan
SLM	Sustainable Land Management

Abbreviations

SLM-IS	Sustainable Land Management-Information Systems
SLM-CB	Sustainable Land Management – Capacity Building
SLM-KM	Sustainable Land Management – Knowledge Management
SLM-R	Sustainable Land Management Research
SPAOPF	Scientific Production Association of Ornamental Plant Industry and Forestry, Uzbekistan
SSSARI	State Soil Science and Agrochemistry Research Institute, Uzbekistan
SWEP	System-Wide Eco-regional Program
SWSRPCA	South-Western Scientific Research Production Center for Agriculture, Kazakhstan
TAC	Technical Advisory Committee
TDEM	Time Domain Electromagnetic
ToT	Transfer of Technology
TSSRI	Tajik Soil Science Research Institute
UCRI	Uzbek Cotton Research Institute
UNCCD	The United Nations Convention to Combat Desertification
UNCED	The United Nations Conference on Environment and Development
UNDP	United Nations Development Program
UNEP-GEF	United Nations Environment Program-Global Environment Facility
UNESCO	United Nations Educational Scientific and Cultural Organization
UNCCC	United Nations Framework Convention on Climate Change
URIAME	Uzbek Research Institute of Agricultural Mechanization and Electrification
URIKSBDE	Uzbek Research Institute of Karakul Sheep Breeding and Desert Ecology
USDA	United States Department of Agriculture
WUA	Water Users Association
WWF	World Wildlife Fund
ZEF	Zentrum für Entwicklungsforschung (Center for Development Research), University of Bonn, Germany

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1 Overall program schedule of the research activities of the SLMR-ICARDA country components

Table 1. Time schedule of SLMR project activities 2007-2009

Activities	2007		2008				2009		Status
	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4	Qtr3	Qtr4	
Output 1. CA countries through the application of integrated systems analysis will have greater understanding of the policy, institutional, environmental drivers of land degradation, and will develop a comprehensive research									
1.1 Coordination and monitoring of regional and national research activities in all the five countries through the establishment of multi-disciplinary teams of national and international scientists									
1.2 Common methodology and research approaches for data collection, factor analysis and system modeling developed for the diagnostic activities									
1.3 Orientation workshop for national scientists and enumerators organized									
1.4 Analyses of driving forces, causes, impacts of land degradation in CA countries through participatory diagnosis and integrated system analysis									
1.5 Ex-ante bio-economic modeling combined with extensive stakeholder consultation									
1.6 Mechanisms for local participation in SLM activities researched and established									
Output 2. Research prospectus for SLM research and donor-support for the duration of the CMPF Support Project developed including development pathways, research hypotheses and links with NPFs									
2.1 Integrative research hypotheses formulized by CA countries and research findings for identification of major factors determining comparative advantages of development pathways synthesized									
2.2. Existing development pathways identified using cross-country analysis and incorporated into NPFs									
2.3 Development pathways that are strongly associated with land management options (mainly resource conservation practices) identified									
2.4 Major development domains using GIS tools and potential benchmark sites identified in each CA country									
2.5 Ex-ante analysis of potential trade-offs between competing interests and the implications for different options									
2.6 A draft research prospectus developed based on the results of activities 2.1 – 2.6. through multi-stakeholder workshops									
2.7 National scientists trained through on-the-job and specialized courses									

Overall program schedule of the research activities

2.8 Simple tools for local assessment and monitoring of land degradation developed									
Output 3. Research projects initiated in benchmark sites in all five countries of Central Asia and options tested with the land users									
3.1 Benchmark sites identified for each of the development pathways having strong association with land management aspects and using cross-country approach									
3.2 Digital database of benchmark site using GIS tools for monitoring and further outscaling developed and available to CA countries									
3.3 Alternative livelihood and land management options selected and tested that provide quick and effective evidence of their benefits in a community-based participatory approach involving young scientist									
3.4 Community arrangements for managing common pool and land resources and potential institutional options identified									To be discussed with communities
3.5 The impact of different alternative land management options on livelihood and environment monitored									
3.6 Alternative SLM options demonstrated to broad audience of stakeholders									
3.7 Ex-post analysis of trade-offs between competing interests and the implications for each development pathway									
3.8 Alternative policy and institutional options to support adoption of SLM practices developed through combining policy analysis with field results									
3.9 Young national scientists trained through on-site and specialized training									
a									
4.1 Extension/advisory services established under each national coordination council									To be discussed with council
4.2 Mechanisms for upscaling and outscaling of SLM strategies and practices identified and analyzed across the CA countries									
4.3 Outscaling mechanisms assessed and tested through participatory action research and ex ante assessments									
4.4 Mechanisms of wider community involvement, public awareness and advocacy campaign such as Farmers' Fairs, Field Days, Farmers' Schools etc. tested in the CA countries									

2 Kazakhstan research report

2.1 Kazakh research team

Table 2. Kazakh research team - Benchmark site 25 and 26 (Abylay and Kaptagay)

National Coordinator, Soil Scientist, Soil and Agrochemistry Science Research Institute after U.U. Usmanov (SASRI) under the Ministry of Agriculture of the Republic of Kazakhstan	A. Saparov
Site Coordinator, Soil Scientist, Chief Research Officer, SASRI	A. Otarov
Responsible Investigator, Ecologist, Ex-Director of Priaral Research Institute of Agroecology and Agriculture (PRIAA) under authority of South-Western Scientific Research Production Center for Agriculture	T. Karlikhanov
Responsible Investigator, Soil Scientist, Head of Reclamation Division, Chief Research Officer, SASRI	M. Ibraeva
Responsible Investigator, Hydraulic Engineer, Head of Department, Natural Resources and Sustainable Development Research Institute (NRSDRI) under Kazakh National Agrarian University	A. Rau
Senior Scientist, Rice Breeder, PRIAA	K. Bakiruli
Senior Scientist, Agrochemist/Soil Scientist, PRIAA	X. Jamantikov
Senior Scientist, Soil Chemistry Scientist, PRIAA	M. Vilgelm
Senior Scientist, Hydraulic Engineer, NRSDRI	E. Kalibekova
Senior Scientist, Hydraulic Engineer, NRSDRI	R. Kablanov
Junior Research Assistant, Geographer, SASRI	A. Virakhmanova
Site Coordinator, Plant Specialist, Chief Research Officer, South-Western Scientific Research Production Center for Agriculture (SWSRPCA)	A. Seitkarimov
Head of Jambyl Department, SWSRPCA	A. Karinbaev
Senior Scientist, SWSRPCA	S. Kuserbaeva
Agricultural Economist, Deputy Governor of Sarysui district of Kazakhstan	S. Tokaev
Farmer of Abylay farm	K. Ayapova

2.2 Time schedule of research activities in Kazakhstan 2007-2009

Table 3. Time schedule of research activities in Kazakhstan 2007-2009

Kazakhstan	Qr3	Qr4	Qr1	Qr2	Qr3	Qr4	Qr1	Qr2	Indicators	Outcomes
1. Evaluate current status of land degradation on the irrigated areas of “Kaptagay” LLC, Kazakhstan	X	X	X	X					Annual reports	Farmers start practicing DSR and afforestation technologies in the neighboring areas to improve quality of natural resources Institutions use the methodologies of comparative evaluation of SLM interventions
2. Assessment of current soil organic carbon status and potential for carbon sequestration in the irrigated areas of “Kaptagay” LLC, Kazakhstan	X	X	X	X					Bench mark database on land degradation	
3. Study the effect of irrigation schedules on rice yield, irrigation water saving and soil salinity				X	X	X			Reports on C stocks and potential for C sequestration	
4. Study the effect of different border dimensions on salt-water balances in rice for saving irrigation water and decreasing salt buildup				X	X	X	X	X	Direct-seeding of dry rice (DSR)	
5. Evaluate the performance of new rice cultivars developed in Kazakhstan and the Russian Federation				X	X	X	X	X	New cultivars for rice yield improvement	
6. Calibration and use of the Greenseeker for measuring crop development, comparing crop management practices and efficient nitrogen management				X	X	X	X	X	Methodology for assessment of agronomic and crop management interventions on growth and land quality	
7. Evaluate the performance of different trees, shrubs, grasses and fodder crops in sub-mountain plains, sand areas in the Abylay area	X	X	X	X	X	X	X	X	Technologies for rehabilitation of saline soils	
8. Dissemination of results and developing mechanisms for upscaling and outscaling of the SLMR options			X	X	X	X	X	X		

2.3 Kazakhstan: Activity 1. Evaluation of existing conditions of degraded lands on the irrigated lands of the company Ltd. “Kaptagai and K” in the Shieli irrigation area

2.3.1 Introduction

1. In Kazakhstan the main irrigated areas are situated in the lower parts of Syrdaria, Ili and other big rivers. It is well known that the lower parts of those rivers are the area of final geochemical flow and have initial relict character of salinization. Therefore favorable condition of irrigated areas in the Republic is first of all linked with their soil-reclamation conditions.

2. According to preliminary data at present period the overall soil salinity process is being observed. Practically in all irrigated areas the positive saline balance exists, secondary salinity of expensive engineering prepared reclamation soils takes place. Only in Kazakhstan part of Aral area due to secondary salinization during 1951-1990 soil fertility reduction has occurred, as a result of secondary salinization of 62 thousands ha. During same period due to flooding and secondary salinity on 12 thousands ha of irrigated area became unproductive saline deserts (Meirmanov, 1996). This resulted in the fact that during recent years on reclamation lands which are expensive engineering prepared lands so called “waste” lands, “fallow” secondary saline, and swamp lands have appeared which are practically out of agricultural land use and gradually are becoming weeded with reed, bushes and galophytes. Namely in Kzylorda region 58.8 thousands ha are not used which constitute over 20% of area of engineering prepared lands (Zubairov 2002).

3. At present period on the main rice growing areas in the Republic the positive water-saline balance is observed, simultaneous secondary salinity, swamping and desertification of lands takes place (Otarov, Ibraeva 2007). Positive saldo of saline balance is observed everywhere. Besides, in conditions of overall increase of human activities impact on the environment which often has a negative character, the condition is deteriorated also due to contamination of soil surface by organic and mineral contaminators. Intensiveness of degradation processes has reached such levels, in which self restoration of soils becomes impossible.

4. Direction of soil formation process depends mainly on how it is used and on intensiveness of activities on culturing of soil. Its transformation can happen both in direction of development of cultural soil formation process and soil fertility increase as well as in soil degradation and soil fertility reduction. In this regard it is necessary to conduct evaluation of existing condition of soil surface in rice areas, identify the reason of degradation and develop activities on protection and restoration of their fertility.

2.3.2 Research aim

- to evaluate the existing condition of soil surface in Shieli irrigation area and development of scientific bases of technology of directed regulation of soil formation process.

5. In this regard in the frame of the Project we have conducted 1:25000 scale soil-reclamation shooting activities on investigating of soils of Company Ltd. “Kaptagai and K”.

2.3.3 Materials and methods

2.3.3.1 Experimental site

Geographic situation

6. Shieli area is situated in pre-delta part of Syrdaria river basin. It covers territory of rice growing area in this region, the takyr-sandy valley Darialyk-Takyr, lower parts of the Sarysu river, South-West areas of the Northern Karatau and part of sandy area in the Kyzylkum. In the north and west it has boundaries with the Syrdaria district of the Kyzylorda region, in the south- Republic of Uzbekistan and in the east- the Zhanakorgan district of the Kyzylorda region and the Suzak district of the South-Kazakhstan region (Figure 1).

Geomorphology

7. Geomorphologic conditions of the area are distinguished with various relief forms. It includes two typical big geomorphologic regions –mountain and valley. Mountain region includes eastern and north-eastern parts of territory and is represented by the North Karatau range. This range relief is presented by deep dissected denudation-tectonic complex. Valley part within investigated area is represented by weak wave denudation valley with hilly relief forms, erosion sloping dissected elevated valley with hilly relief forms and even accumulative valley-floodplains and floodplain terraces of river valleys. One can also see erosion-accumulative takyr and lake depressions. (Figure 2).

Natural zoning

8. Research area is situated in desert zone of the vast Turan lowland. Climate is sharply continental: hot dry summer and cold winter with snow. The area is very dry, precipitation 152-159 mm per year

1. Pre-mountain area and low mountain zone of Karatau. The Karatau mountains are located within north-west boundaries. The lower parts of northern sub-mountain areas with absolute height of 180-300 m are covered with *boyailich* plants. The higher and closer to the mountains, the more worm wood plants grow.
2. Desert right bank zone covers the Sarysu delta saline deserted and the Darialik-Takyr old alluvial valley districts. Northern desert is almost an ideal valley. Vast takyr with spots

of takyry-type saline and marsh and alkaline soils are prevailing. Groundwater at the depth of 7-10 m is saline. Pastures are scarce, waterless, autumn-spring type.

3. Central land cultivation zone. Shieli irrigated area with intra-zone hydro-morphic soils and marsh soils. District of intensive developed irrigation.
4. Desert left bank zone. Kyzylkum district of ridge-hillock fixed, in some places weakly fixed and sand-dune unfixed sands. Sands have complicated ridge-hillock relief. Soil formation process is weakly expressed, differentiation of profile on soil horizons is missing.

Soils

9. Soil surface formation of the Hungry steppe is subject to the peculiarities of vertical natural zoning and intra zone factors related to the activity of the Syrdaria river. Below is given the brief description of profiles of the main genetic types and their physical and chemical features (Figure 4).

10. Ordinary northern serozems are formed mainly within flat sloping surfaces of pre-mountain valleys of Northern Karatau under cereal-wormwood plants. Non saline two component deposits of various genesis serve as soil forming rocks which have small capacity loam horizon on top, on small depth underlying by rubble rocks. Soil profile is characterized by humus horizon (A) with average capacity of grey color, grey-brown color of transferable humus horizon (B); sharply expressed carbonate-illuvial horizon laying in contact with underlying rock; Serozems contain humus: from 1.03 to 1.1 and nitrogen 0,07%. Down on profile content of N reduces. Quantity of absorbed foundations fluctuates from 5.35 to 8.68 mg-eq per 100 g of soil. In content of absorbed foundations the role of calcium is prevailing. Distinguish in rubble type of upper loam horizons. In content of melkozems particles of small sand and large dust prevail.

11. Sero- brown soils occupy slopes of not high hills and some on south-west pre-mountain areas of Karatau. They develop in tertiary chalk deposits under wormwood-boyalich plants. Covered with pebbles in profile there are pebbles and rubble. Upper horizon has grey color, horizon B is brown or brown color, lower is brown color. From depth 25-30 cm spots of carbonate appear. Down is gypsum. These soils have slight mechanic composition. Fractions from 1 to 0.05 mm i.e. sand fractions are prevailing on the whole profile. Sero-brown soils are poor on nutrient substances. They include low humus (about 1%) and nitrogen.

12. Takyry type soils within Shieli area are represented mainly with marsh-alkaline type. Takyry type marsh alkaline soils occur on both banks of Syrdaria river mainly on early alluvial valley Darialik-Takyry occupying flat areas. Along whole profile there are salt spots. They are distinguished with high alkaline maximal salinization is up to 2.5-3% in average part of profile (70-100 cm), lower and upper- less. Salinization has sulphate character in which Ca and Na prevail. Humus is less than 1%. On the depth of 20-70 cm marsh horizon is outlined which

coincides with horizon of maximal salt accumulation including 18% Na from total absorbed foundations. Under salt horizon there is about 9% of gypsum distribution of carbonates is even (less in gypsum horizon – 4.7%).

13. Takyrs on the territory of the Shieli area are met on the territory of old alluvial valley Darialyk-Takyr in complex with takyr type soils. Soil forming rocks are delluvial clay and loams, underlying usually by layer of old alluvial deposits, heavier on the top and more light in the depth. Takyr with pores firm surface crust, heavy mechanic composition, weak salinization (0,4-0,8% of firm residue) with excessive chlorides. Less than 0.7% of humus. Total amount of absorbed foundations -8,9-13,9 mg-eq, on the top Ca is prevailing, with 20 cm-Mg in under crust horizon –up to 19,7% of absorbed sodium from the sum of absorbed foundations.

14. Alluvial-meadow soils on the territory of Shieli area have developed in the valley of Syrdaria and Sarysu on alluvi of various mechanic compositions. Soils are in conditions of constant moisture from riverbeds of Salinity is surface, sulphates with prevailing HCO₃, Na and Ca.

15. Meadow-swamp soils represent a special phase of hydromorphic soils and constitute main land base of irrigated land cultivation in pre-delta of the Syr Darya river. These are mostly deposits of various age. They are spread in central part of pre-delta, in wide and flat depressions. They form complexes with swamp soils and together constitute a dynamic system of their existence and transfer into each other depending on hydrologic regime. They are distinguished with clearly expressed humus horizon. In the upper part of the profile oxidation process is prevailing, in the lower part –restoration process. Humus content is 2.7%, it is evenly spread on profile. Weak salinization, maximum relates to the upper part of profile, on chemical salinization it is chloride-sulphate, from cations almost everywhere Na prevails.

16. Marsh soils in pre-delta are met mainly in the valley of the Syr Darya river and lowlands of Sarysu river. They are divided into marsh typical, sor and meadow. The Marsh typical occupy high reliefs and are met in complex with alluvial-meadow and meadow-swamp soils. On mechanic composition they are various and flaky. Dry residue till depth of 2 m do not exceed 1%. Marsh sor soils are met mainly in wide depressions on salt rocks. In these marshes there are two salt maximums: in upper and low levels, dense residue in upper horizon fluctuates from 6 to 15%. On profile gypsum is clearly seen, but on composition it concedes to chloride salts.

17. Marsh meadows are spread mainly in watered zone of Syrdaria valley and low stream of Sarysu river as well as near lake zone. On mechanic composition they are diverse but layers of light composition prevail. Salinization is sulphate especially in upper part of profile till depth 50 cm, where dry residue is higher than 3%. From cations Na is prevailing, humus is higher than 2%. They can be easily washed and used for growing agricultural crops.

18. Sands on territory of the research object occupy big areas and are represented by desert firm and weakly firm and not firm sand-dune, hillock, ridge-hillock sands. They are the part of a big sandy area- eastern Kyzylkum and island sands Alkakums which are spread mainly on old alluvial valley Darialyk-Takyr.

Natural landscapes

19. Thanks to contrast natural conditions, existence of mountain chain, Syr Darya river, natural landscapes of Shieli area distinguish with big diversity of species (picture 5). In mountain part the natural landscapes are represented by low mountain steppe and pre-mountain desert types of landscapes. Valley landscapes are represented by desert type of high and low valleys. On both banks of Syr Darya river in conditions of hydromorphic regime the intra zone valley type of landscape is spread which is represented by floodplain from clay, loam and sands with bushes, meadow and galophyt –meadow plants.

20. Source of irrigation water in the area is Syr Darya river. Water is given by Novoshieli highway channel with capacity in the beginning of channel $122 \text{ m}^3 \text{ s}^{-1}$ (Figure 6). It was built in land channel and has low coefficient of useful capacity. Total length of channels of all types is 760 km. Water flow of drainage-runoff waters is done by five collectors and Telikul irrigation channel. There exist 140 wells of vertical drainage but no one is operating at present time.

21. Saline soils of various salinization of the company Ltd. “Kaptagai and K” on territory of Shieli irrigation area have served as a direct research object. Main production direction of the farm is crop production. Arable area is 1831 ha of engineering prepared lands. Within the structure of arable lands main crop is rice (Table 4). As rotation crops for rice the following crops are grown: main crop before rice is alfalfa and after rice winter wheat is planted. In the farm two 8 field (#3 and 5) and one 4-field (#4) rice-alfalfa rotations are used.

22. Under rice plantations here marsh and meadow-marsh soils with various salinization were used. As a result of long term use for rice production those soils have evolution according to classification of Kazakhstan soil science specialists (Borovsky 1959; Karazhanov 1973; Volkov 1983) to irrigated (rice) marsh soils. Changes in soils under this crop are related to specific conditions of its growing- periodic long term flooding and drying. On type of salinization the soils are chloride-sulphate with significant prevailing of sulphates. Saline regime of soils comprises summer washing cycle (during flooding of fields) and autumn cycle of salinization restoration (after irrigation period).

23. As the Research of water-saline regime of soils have shown, the restoration of initial salt content in unfavorable reclamation situation which is regrettfully observed during last years everywhere, can occur less than year after harvesting of rice. Described soils are characterized with content 1.2-2.4% of humus. Humus profile of soils is reverse and is much extended. Significant humus quantity (about 1%) can be found on depth of 1 m and lower that is not typical for other soils. Within plough layer of soil in rice fields the changes can be found, which

appeared after flooding: grey very thin surface layer 0-1(2) cm, in which aerobe processes are observed; black iron-sulphide horizon 1(2)-5 cm, sometimes second ferric sulphide horizon on depth 16-19 cm or some spots up to 30 cm; whitish-dove horizon 5-20 (30) cm. So, we can say that *irrigated (rice) marsh soils* on morphologic features are characterized as very diverse on profile and very changeable in time.

24. Soil formation processes on the territory of the research object occur in conditions of desert climate which is distinguished with significant continental character and insignificant quantity of atmosphere precipitation (not more than 100 mm per year), high evaporation (1500-1700 mm per year), high summer and low winter temperatures and significant amplitude of fluctuation of daily temperatures. Therefore land cultivation is possible only if irrigation is available. Availability of water is the crucial condition which determines productivity of agriculture and soil formation process.

25. Big influence on yield capacity of grown crops and soil formation direction has management and regulation of water balance elements in the territory in whole.

2.3.3.2 Methodology

26. For solving the settled tasks we have used widely spread and well tested methodological approaches and methods of complex study of soils.

27. In studying of features of soil formation in conditions of periodic flooding of soils the *comparative-geographic method* and *method of soil keys (regime sites)* was used. These methods allow providing characteristics of big territories with one type structure of soil surface based on detailed analysis of small representative sites-keys. In research of concrete soils the morphologic and profile methods were used which are the basic methods in conducting field soil Research and serve as a basis for field diagnostics of soils.

28. Evaluation of saline soils was based on 3 main criteria: chemical (type) of salinization, rate of salinization and depth of saline horizon. Chemical feature of saline soils was determined by anions and cations composition. First of all anions were taken into consideration, units of their relations in water extract of soils [1,2,3,4].

2.3.4 Results and discussions

29. Main aim of research on this object is evaluation of existing soil and reclamation condition of the area and making the list of reclamation activities on improvement of their reclamation condition and productivity of agricultural crops (sustainable management of land resources).

30. For implementing this work in fall 2007 on territory of the research object the saline shooting was conducted and appropriate map was developed (Figure 7). As a result of conducted saline shooting it was identified that on the territory of company Ltd. "Kaptagai and

K” practically all soils have a certain rate of salinization. Almost on a half of area (54.5%) of the farm marsh weak saline rice-marsh soils are frequent (Table 5). Further in descending order average and heavy saline soils are met. Insignificant area is occupied with marsh and deep marsh soils. Most part of farm area (88.5%) are saline soils on surface that is a result of the existing irrevocable secondary salinization of these soils (Figure 8). On heavy saline soils always rare germinations occur and respectively low yields of rice (Figure 9).

31. As a result of conducted evaluation of existing condition of the rate and chemical feature of saline soils and depth of saline horizon on the territory of company Ltd. “Kaptagai and K” critical territories of saline soils have been identified. Such territories are ends of all fields of 3-d rotation adjusting to collector of drainage waters of 3-d and 4th rotation. This shows that technical condition of this collector doesn’t correspond to project norms i.e. collector’s devices are worn out, depth and section don’t provide runoff of drainage waters. As a result the raise of the level of Groundwater to critical mark and soil salinization take place.

32. For identifying influence of the rate of soil salinization on yield capacity of rice in fall 2008 after harvesting the average yield capacity of rice on rotation field (Figure 10 and Table 6) has been identified. As it is shown from the scheme of rice plantations location on shape of heavy saline soils rice was grown only on one field, 4th field of 3-d rotation and here low yield of rice was harvested 20.6 centner ha⁻¹. Besides on this field rice was grown on alfalfa rotation. It is known that availability of organic substance in soils is one of leading factors that influence effectively on soil fertility of rice fields.

33. On background of weak and average saline soils most high yields of rice (42.4-51.5 centner ha⁻¹) have been harvested on 3-year alfalfa. Low yields of rice in 5th and 8th fields of rotation are caused by the effect of close level of Groundwater due to non effective work (worn out devices of channels, channel sections don’t correspond to project marks, weeds etc.) of group collector of 5th rotation.

34. In such conditions temperature of soil of root growing layer is always lower than in fields with normally working collector-drainage network. Besides definite impact had saline soils (of average and weak rate of salinization) and the fact that before rice here also was alfalfa rotation i.e. the impact of negative factors that on soil fertility takes place.

2.3.5 Conclusion

35. As a result of conducted evaluation of existing condition of the rate and chemical feature of saline soils and depth of salt horizon on the territory of company ltd. “Kaptagai and K” the critical territories on soil salinization have been identified. Also by using analysis of Rice Yield on rotation fields it was identified that soil salinization rate is one of the main factors of yield reduction.

36. The developed map of saline soils is given to the staff of company ltd. “Kaptagai and K” for practical use.

37. Based on comparative analysis of saline rate and other factors of soil fertility and rice yield capacity we can say that one of the main directions of effective management of irrigated land resources on all levels from concrete land owner to the government in whole should be the restoration of soil fertility of reclamation soils. Therefore we consider that for identification of deterioration of soil –reclamation condition of irrigated areas the same research of monitoring type should be conducted systematically but not occasionally. That research should be complex inter-disciplinary with participation of soil scientists, reclamation specialists, hydro-geologists, land cultivation specialists, crop production specialists, breeders, plant physiology specialists and others.

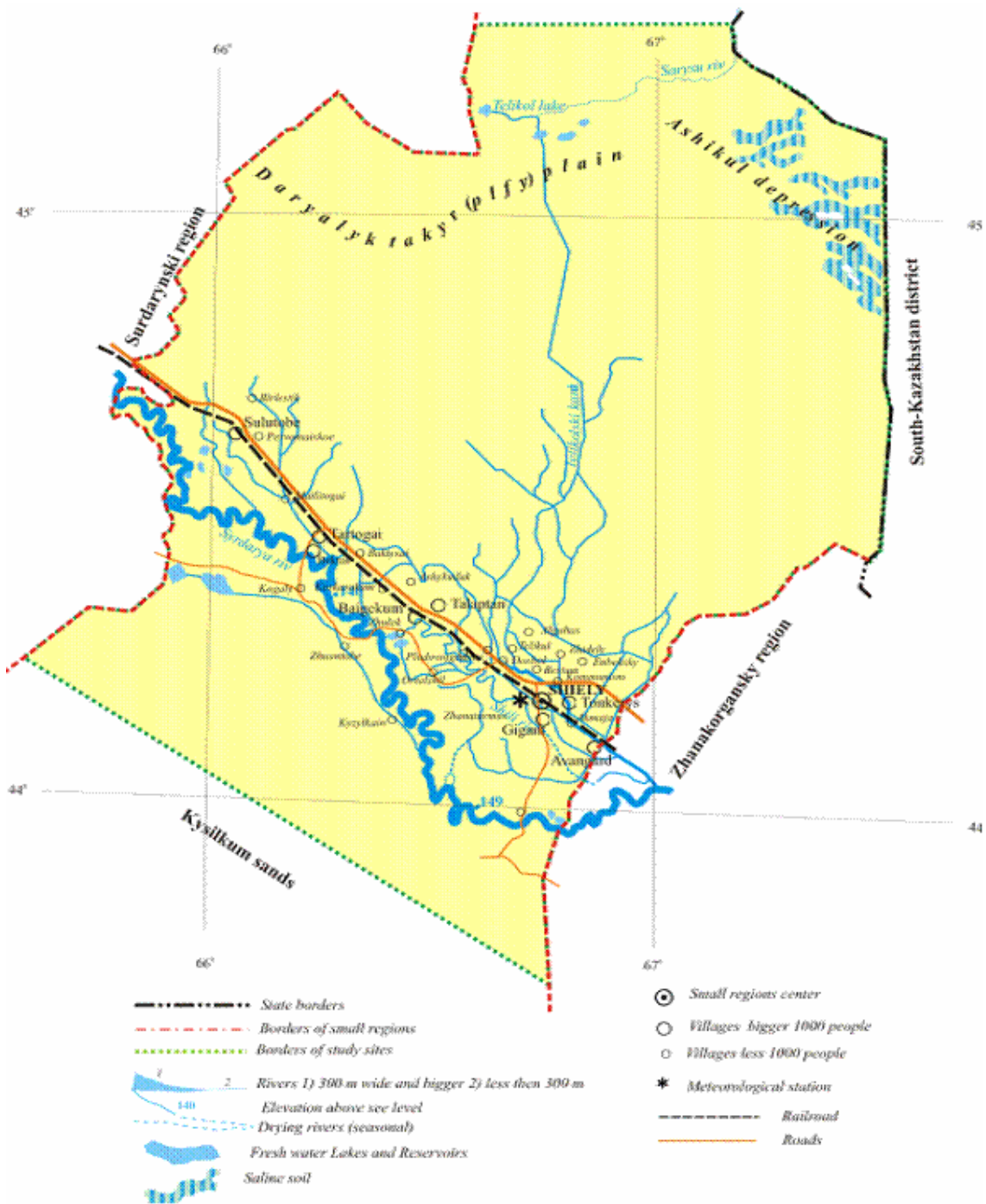


Figure 1. Administrative map Shieli massif

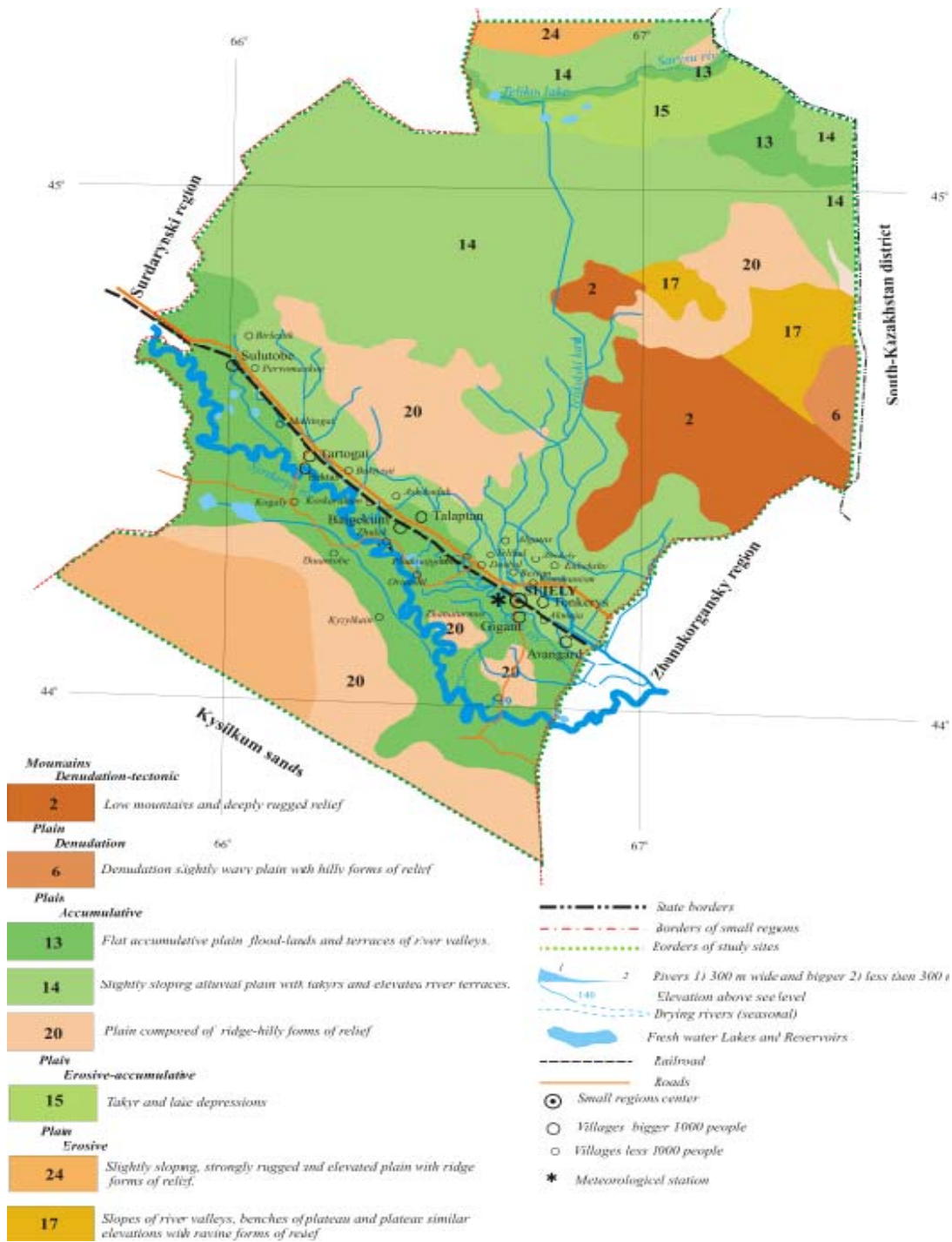


Figure 2. Geomorphologic map Shieli massif

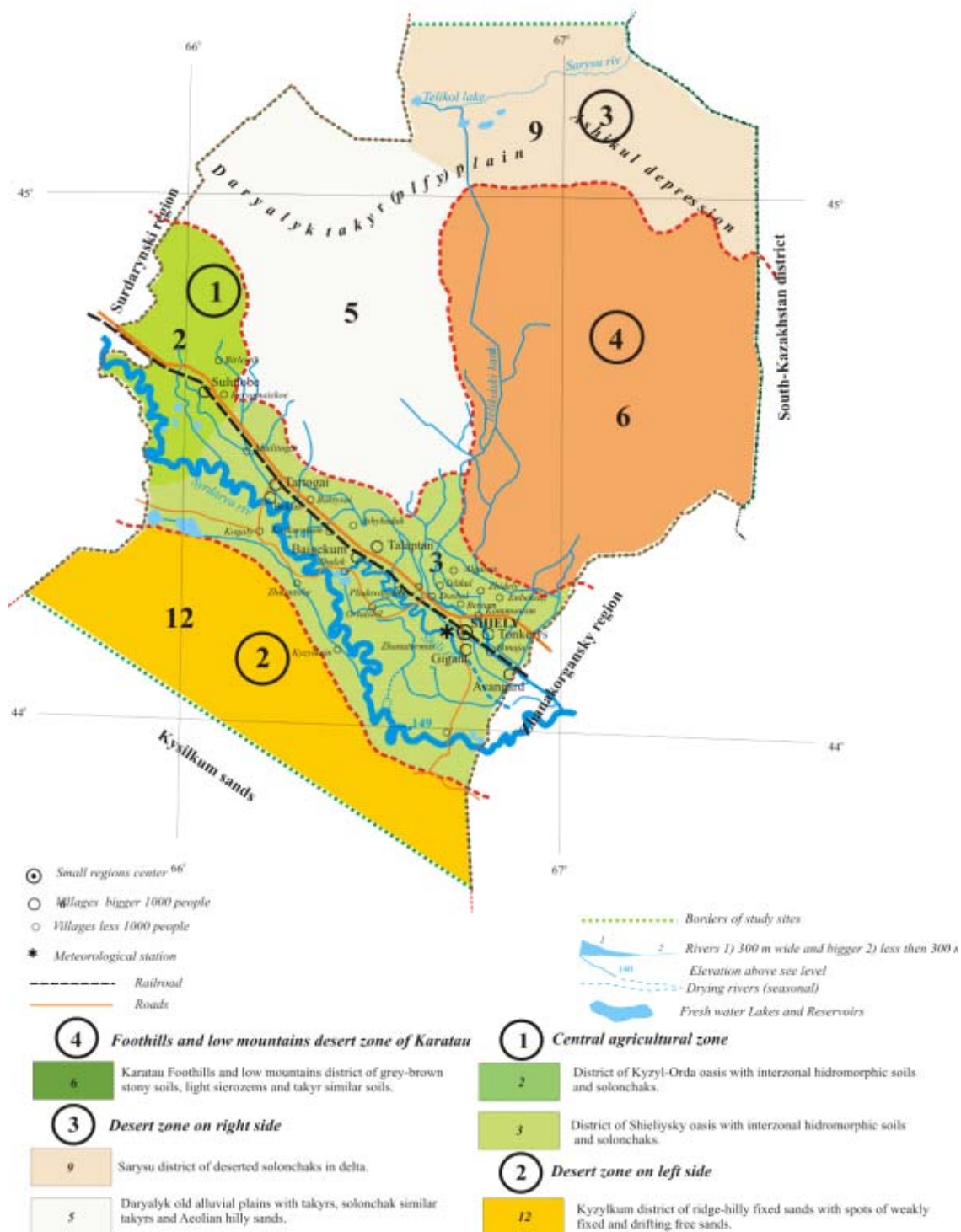


Figure 3. Natural zones map Shieli massif

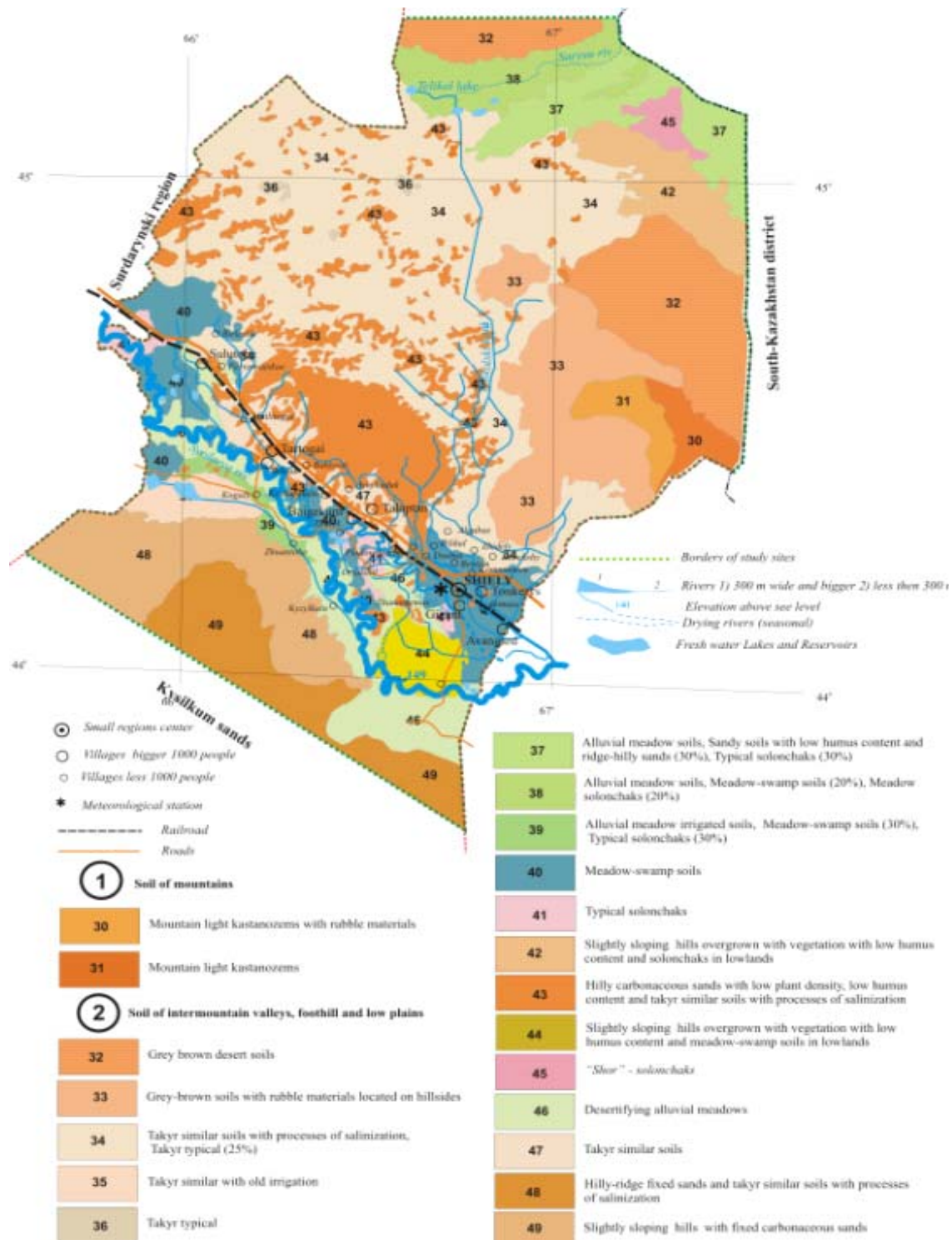


Figure 4. Soil map Shieli massif

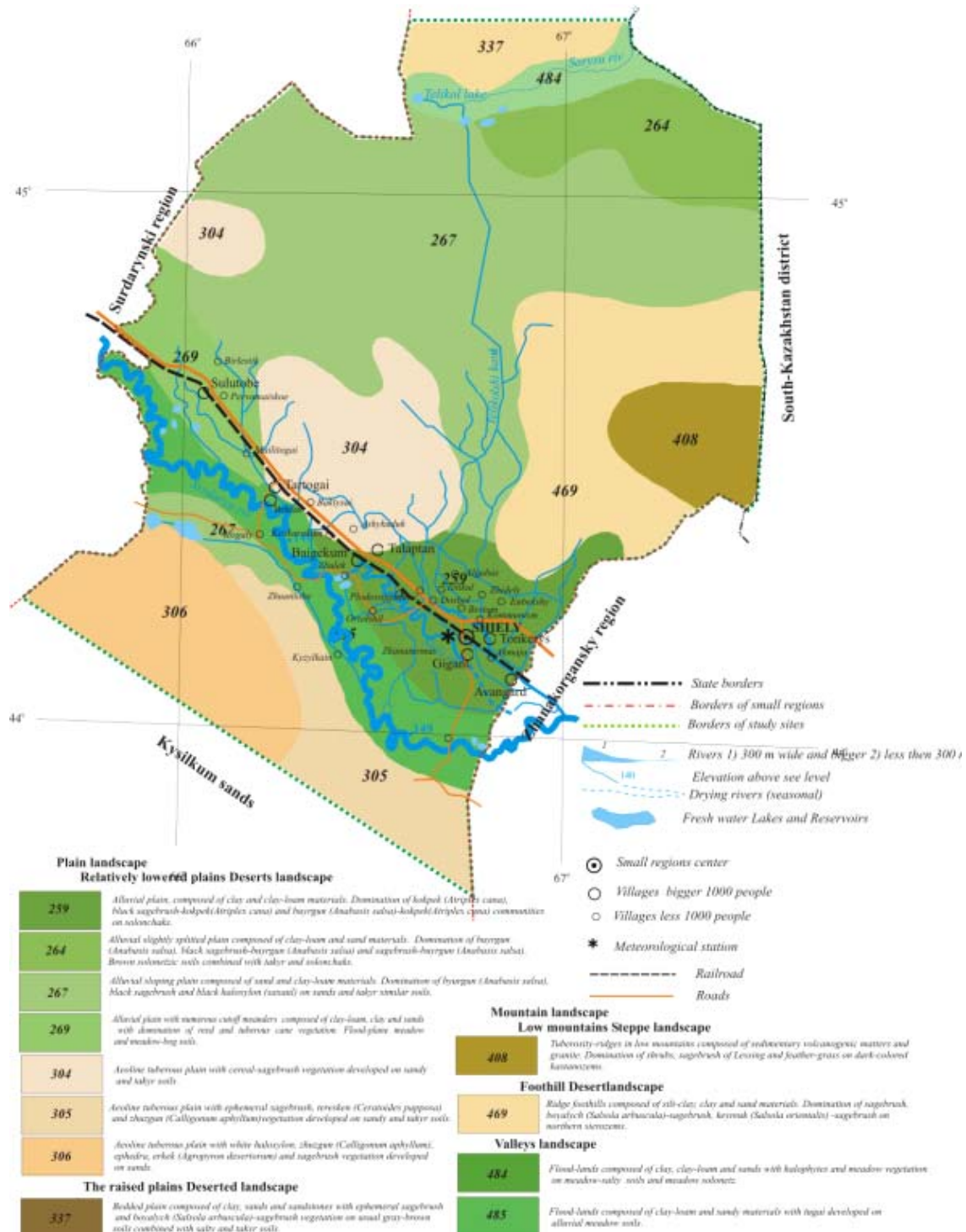


Figure 5. Landscape map Shieli massif

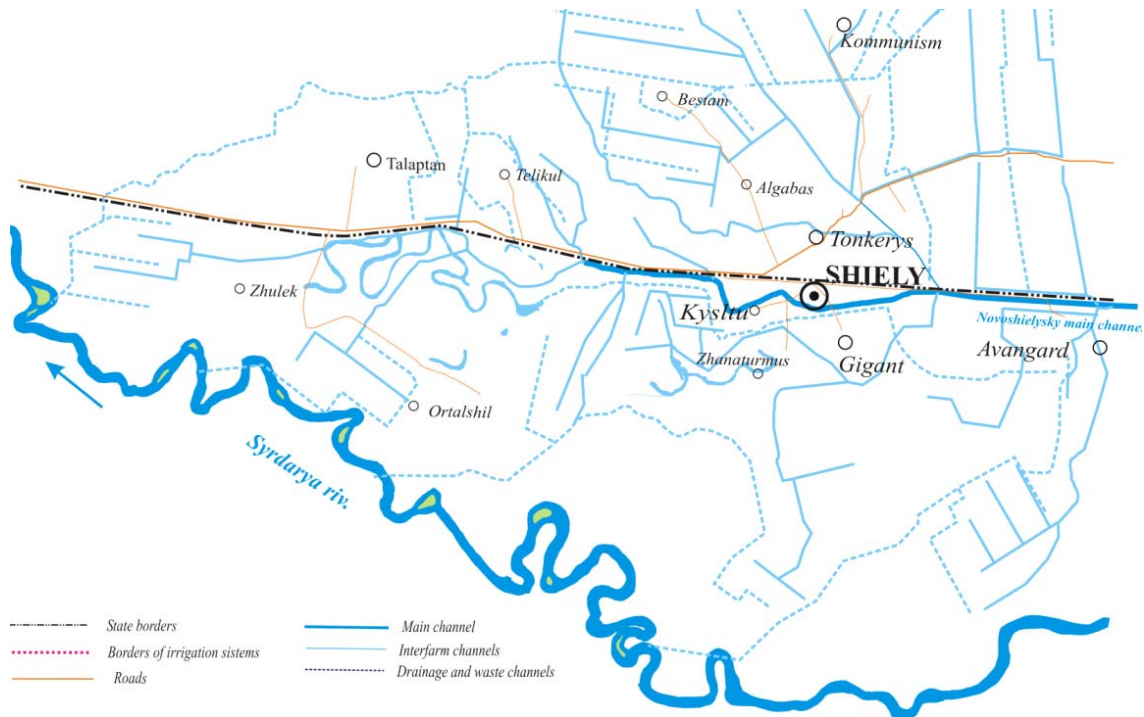


Figure 6. Scheme irrigation to network Shieli massif



Figure 7. Cartogram salinity soil TOO "Kaptagay and Co"



Figure 8. Abandoned secondary saline soils



Figure 9 Rarified rice plantations on saline soils

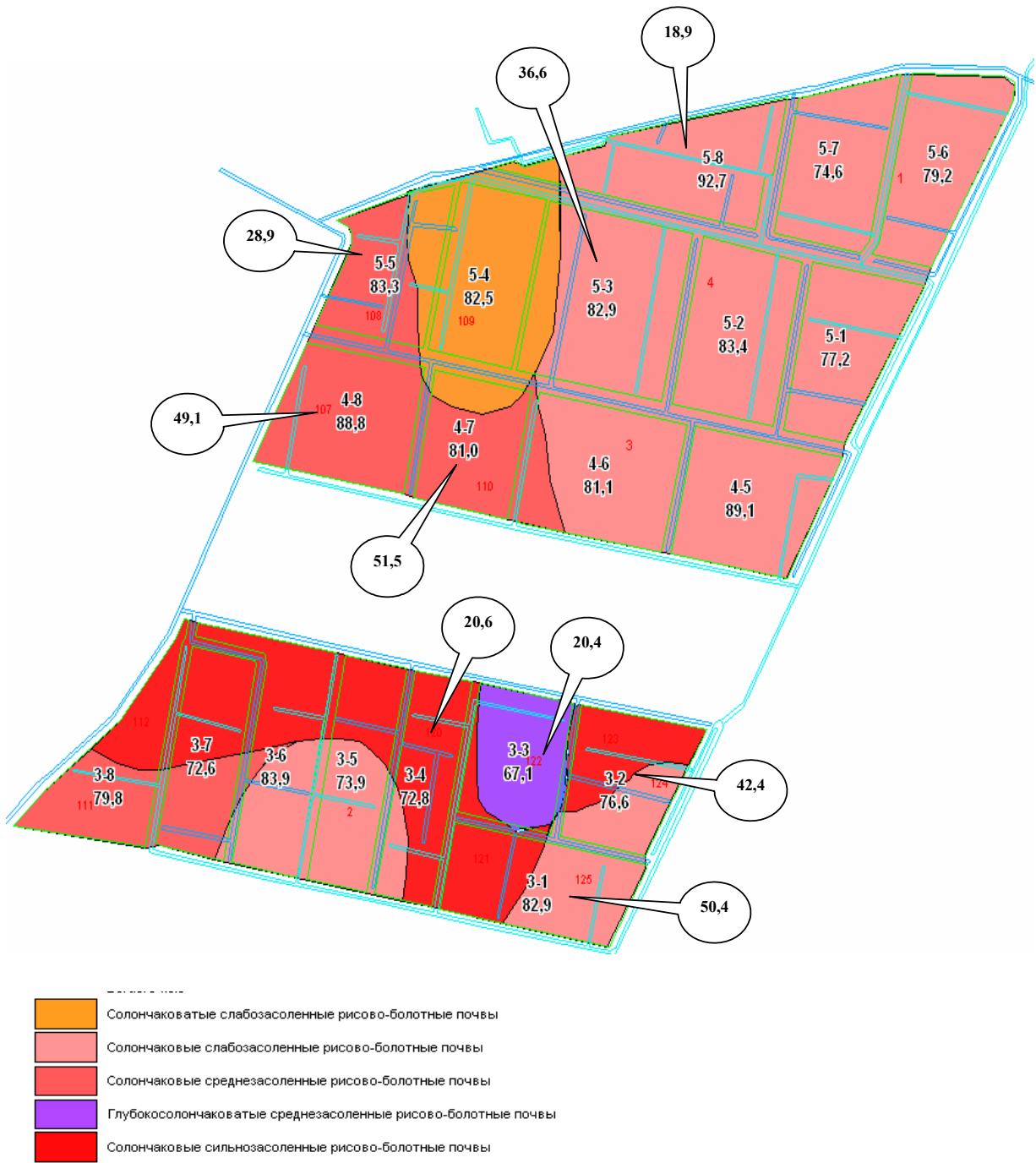


Figure 10. Soil salinity map and rice yields on the Kaptagay farmer holding

Table 4. Structure of the planted area within the Kaptagay farmer holding

#	Crops	Area	
		ha	%
1	Rice	1046.0	57.1
2	Alfalfa of previous years	324.0	17.7
3	Alfalfa of current year	380.0	20.8
4	Wheat	380.0	-
5	Field under amelioration	81.0	4.4
Total:		1831	100

Table 5. Area of saline soils on Kaptagay farmer holding

Soil contours	Area	
	ha	%
Solonchak slightly saline soils (0-30 cm)	998.0	54.5
Solonchak mid saline soils (0-30 cm)	312.0	17.0
Solonchak highly saline soils (0-30 cm)	311.0	17.0
Slight saline soils within the layer of 30-50 cm	155.0	8.5
Mid saline soils within the layer of 50-80 cm	55.0	3.0
Total	1831.0	100.0

Table 6. Productivity and gross yield of rice on Kaptagay farmer holding

Crop rotations	Fields	Previous crops	Area, ha	Yield, centner ha ⁻¹	Gross yield, ctn
3	1	Layer of alfalfa grown for 3 years	73	50.4	3679.2
	2	Layer of alfalfa grown for 3 years	69	42.4	2925.6
	3	Оборот пласта 3-х summer alfalfa	59	20.4	1203.6
	4	Оборот пласта 3-х summer alfalfa	64	20.6	1318.4
4	7	Layer of alfalfa grown for 3 years	71	51.5	3656.5
	8	Layer of alfalfa grown for 3 years	77	49.1	3780.7
5	3	Оборот пласта 3-х summer alfalfa	72	36.6	2635.2
	5	Оборот пласта 3-х summer alfalfa	73	28.9	2109.7
	6	Оборот пласта 3-х summer alfalfa	62	18.9	1171.8
Total			620		22480.7

2.4 Kazakhstan: Activity 2. Evaluation of humus condition and provision of soils with main nutrition elements in irrigation lands of the Company Ltd. “Kaptagai and K” in Shieli area”

2.4.1 Introduction

38. At present the radical damage of the earlier assimilated rice-alfalfa rotations took place, areas under alfalfa which grew before rice have reduced sharply, that has resulted on humus condition of soils. Humus content in soils of Akdala rice growing area has reduced in comparison with initial condition to 19.3-24.7% (Otarov 2007, Ibraeva 2007). In soils of old irrigated rice areas in Kyzylorda region humus reduction during last 30 years is 30-40% and at present on 60% of arable lands its content is less than 1% (Zubairov 2002). Our research also has shown that in unfavorable environmental-reclamation situation the losses of the most mobile water soluble form of humus per one season are 12-36% (Otarov 2007, Ibraeva 2007).

39. The issue of supply of soils with main nutrient elements is also a problem. In the Republic in 1986 mineral fertilizers were used in amount of 1919 thous. tons, in 1996 only 28.7 thous. tons were applied and stable negative balance of nutrient elements and organic substance occurred (Eleshev 1998). The problem of conservation of soil fertility has become worse.

2.4.2 Research aims

- to investigate the humus condition and availability of main nutrient substances.

In this regard in the frame of this work we have conducted soil-agri chemical shootings works on examination of soils in control sites situated on territories of main rice areas of the Republic. Not only composition of general humus in soils has been subject to evaluation but also water soluble part, rate of dissolubility, humus saturation with nitrogen.

2.4.3 Materials and methods

2.4.3.1 Investigated area

40. The work was conducted on the territory of Company Ltd. “Kaptagai and K” in Shieli irrigation area. Geographic situation, main factors of soil formation etc., natural conditions of irrigated area are described in details below.

41. Research objects included rice-swamp soils of those fields on which rice planting was planned in 2008. These are 5- rotation 4-4-5 and 8 fields, 4-rotation 7 and 8 field and 3-rotation 1,2,3 and 4 fields. Total 712 ha have been examined.

2.4.3.2 Methodology

42. Agrichemical examination of soils was conducted under “Methodological guidance on conducting agrichemical survey of soils of agricultural plots” (2005). Depending on intensity of using mineral fertilizers one mixed soil sample was selected from 3-5 ha.

43. During analysis of soil samples “Method of soil extracts” was used which is based on hypothesis that each dissolvent (water, various acid dissolvent, alkaline or salts of various concentration, organic dissolvent- alcohol, acetone, benzene etc.) are extracted from soil in controlled conditions of interaction a certain group of components of element in which the researcher is interested. Method is especially widely used for study of nutrient elements available for plants, fraction composition of soil humus, mobile compounds in soils, migration processes and accumulation, various chemical compounds of certain elements.

44. In selected samples the identification was conducted of the following- humus on I.V.Turin method, GOST 26213-91, easy hydrolyzed nitrogen, on Kornfield (“Methodical directions..., 1985), mobile compounds of phosphorus and exchange potassium on Machigin method, GOST 26205-91, pH-water extract according to GOST 17.5.01.-84.

2.4.4 Results and discussions

45. During study of value of content and peculiarities of space fluctuations of soil features or average content of any elements in certain soil types or their combination for increasing of reliability of obtained data and conclusions on them the use of methods of statistic analysis of data is very important. Besides, the use of statistical analysis also increases interpretation possibility of the data. It should be noted that all conclusions on absolute units of soil features made on one or several typical cuts without statistic processing of obtained data, often they can be not authentic and can result in wrong interpretation of obtained data [14].

46. Based on the above mentioned the obtained analytical data of the main parameters of humus condition of soils have been subject to statistical processing using Excel packet of analysis.

47. Here we provide variation-statistical indices of humus forms content in soil, nitrogen and their derivable (Table 7). Statistical authenticity of obtained data is confirmed by calculated values of Student t-criteria which showed that on those soils in 95% level of importance the value t_{fact} is significantly higher than t_{tab} . Rather narrow limits of reliability interval also are the indirect confirmation of this fact. Coefficients of variation of the studied features don't exceed average value that speaks of statistical stability of the obtained data. So for evaluating existing condition of soil cover of Company Ltd. “Kaptagai and K” we can use data obtained during research works that are statistically sustainable.

48. As the research results showed soils of Company Ltd. “Kaptagai and K” have very low general humus composition (1.1 ± 0.18 %) and according to soil grouping on composition of

general humus [20], they belong to the group with very low humus composition. In the most mobile water soluble humus form in average contains 0.004 ± 0.0005 %. Important index is dissolubility of soil humus in Shieli irrigation area is equal to 0.4 ± 0.074 .

49. These data serve as a confirmation of the conclusion we have made earlier that in periodically flooded rice soils humus losses occur mainly due to its mobile water dissoluble form due to specific conditions created because of constant flooding.

50. At present soil agrochemical survey remains as a main evaluation indices of the influence both positive and negative of the economic activities on soil fertility. Its conducting allows not only to identify direction of changes of soil fertility processes but also to develop activities on stabilization of soil fertility in each concrete farm. Application of fertilizers on recommendations of agrichemical service increases their efficiency to 15-20% in comparison with application on zone recommendations without consideration of soil-agrichemical conditions of concrete sites.

51. Therefore for evaluating composition of common humus in soils and availability of main nutrient elements on research object agrichemical shooting was conducted on the area of 712.0 ha and appropriate map charts have been developed.

52. Further for detailed agrichemical characteristics of soils in the area and determination of the character of distribution of nutrition elements on the research area we have conducted grouping of soils on composition of nutrient elements with calculation of the area of corresponding groups.

53. As it is seen from obtained data all investigated territory is occupied with group of soils with “very low” (95.8%) and “low” (4.2%) of humus composition. It means that soils in company Ltd. “Kaptagai and K” belong to degradation soils subject to de-humification process in soils (Table 8 and Figure 11).

54. Soils of this farm are also very exhausted by one of the main nutrition elements of easy hydrolyzed form of nitrogen. Almost all (98,5%) investigated territory of the farm on nitrogen composition refers to very low gradation (Table 9), 1.5% to low. Soils with higher nitrogen composition are missing.

55. As we can see from data of Table 10 the soils of the investigated farm territory are very diverse on availability of phosphorus and have all groups on composition of mobile phosphorus: very low, low, average, slight high, high, very high rate. For achieving high yield 45,2% of the areas need phosphorus fertilizers. Also it is necessary to note that such high diversity needs equalization of the background except for supply of plants with available phosphorus form.

56. Potassium reserve of the investigated soils is also rather diverse, more than 90% of the area of investigated soils have average and high rate of availability (Table 11). Alongside with this there are soils with both low and high rate of availability of potassium.

57. Reaction of soil environment is one of the main factors of soil formation process and has a significant influence on growth and development of plants and soil microorganisms, speed and direction of chemical, physical-chemical and biological processes, provides efficiency of fertilizers application. Main part of culture crops better grow in neutral or weak acid reaction of environment. Acid and alkaline medium is harmful for them. From data of picture 2.5 it is seen that pH of investigated soils varies within weak and average alkaline and is one of factors of reduction of soil fertility of these soils.

2.4.5 Conclusions

58. On the results of agrichemical survey of the soils we can make a conclusion that soils on the whole investigated area on humus composition and nitrogen have very low and low rate of availability and refer to category of not supplied and very need organic and nitrogen fertilizers. Availability of mobile phosphorus form and potassium in soils is very diverse and therefore in applying phosphorus fertilizers it is necessary to follow strictly the recommended doses according to map charts.

59. Also we would like to mention that efficiency of fertilizer is high when all technology elements in growing rice are observed- in well organized system of maintaining reclamation conditions in the fields, appropriate preparation of soils to planting, elimination of weak oxidation of soils, qualitative and timely planting of quality seeds, appropriate control of water regime, weed control etc. Insufficient technology cannot be corrected by high dose fertilizer application.

60. As a result of conducted evaluation of existing humus condition of soils and availability of main nutrient elements the detailed report *“On results of agrichemical survey of soils in company Ltd. “Kaptagai and K” in Shieli district of Kzylorda region on Project “Sustainable management of irrigated land resources in Republic of Kazakhstan”* and appropriate map charts have been given to farmers in the beginning of field works in 2008 for practical use and fertilizers under harvest 2008 have been applied according to our recommendations.

61. Report consists of the following chapters: Introduction; General information on farm and natural climatic conditions where climate, soils and characteristics of their main features are given in details; Main results of agrichemical survey of soils with data on grouping of soils on availability of main nutrient elements, recommended norms, terms and methods of fertilizers application under main agricultural crops depending on availability of main nutrient elements in soils and planned yield capacity and recommended activities on soil fertility increase.



Figure 11. Cartogram of the contents humus in soils Ltd "Kaptagay and Co"



Figure 12. Map of easily dissolvable nitrogen content within soils on Kaptagay farmer holding.



Figure 13. Map of mobile phosphorus within the soils of Kaptagay farmer holding



Figure 14. Map of exchangeable potassium within the soils of Kaptagay farmer holding.



Figure 15. Map of soils pH level on Kaptagay farmer holding

Table 7. Statistical indicators of the humus and nitrogen content and their derivatives.

Items	Statistical indicators					V, %
	n	M±m	t-criterion		± t _{0,05} * m	
			t _{факт.}	t _{0,05}		
Total humus, %	15	1.10±0.18	42.6	2.36	0.45	6.2
Water soluble humus, %	15	0.004±0.0005	32.2	2.36	0.0013	8.2
Humus solubility, %	15	0.4±0.074	45.8	2.36	0.181	5.8

Table 8. Soil grouping depending on the humus content on the Kaptagay farmer holding

#	Humus content	Humus, %	Area, ha	% out of area
1	Very low	< 2,0	682,0	95,8
2	Low	2,1 – 4,0	30,0	4,2
3	Moderate	4,1 – 6,0	-	-
4	High	6,1 – 8,0	-	-
5	Very high	> 8,0	-	-
Total	-	-	712,0	100,0

Table 9. Soil grouping depending alkali hydrolyzed nitrogen defined on the basis of Kornfield method.

#	Nitrogen content	Nitrogen mg kg ⁻¹	Area, ha	% out of the area
1	Very low	100	702.0	98.5
2	Low	101 – 150	10.0	1.5
3	Moderate	151 – 200	-	-
4	High	200	-	-
Total	-	-	712.0	100.0

Table 10. Soil grouping depending on content of mobile phosphorus

#	Content of mobile phosphorus	P ₂ O ₅ , mg kg ⁻¹ of soil	Area, ha	% out of the area
1	Very low	< 10	-	-
2	Low	11-15	10.0	1.4
3	Moderate	16-30	60.0	8.4
4	High	31-45	252.0	35.4
5	Very high	46-60	280.0	39.4
6	Extremely high	> 60	110.0	15.4
Total	-	-	712.0	100.0

Table 11. Soil grouping depending on the content of exchangeable potassium

#	Potassium content	K ₂ O mg kg ⁻¹	Area, ha	% out of the area
1	Very low	< 100	-	-
2	Low	101 – 200	50.0	7.0
3	Moderate	201 – 300	350.0	49.2
4	High	301 – 400	292.0	41.0
5	Very high	401 – 600	20.0	2.8
6	Extremely high	> 600	-	-
Total	-	-	712.0	100.0

2.5 Kazakhstan: Activity 3. Studies on the effect of irrigation schedules on rice yield and savings in irrigation water and salinity of ponded waters and soil profile¹

62. This research activity was excluded from the workplan in 2009 due to restricted funds available and after discussion with the project coordinator, Dr. Kirsten Kienzler. Results from the year 2007 are available under the following link

http://www.icarda.org/cac/files/slmr/ADB_TA_6357_SLMR_1st_Ann_Rep_2008_RUS.pdf.

¹ Из-за недостаточного объема финансирования по согласованию с Региональным координатором проекта ИКАРДА доктором К. Кинцлер в 2009 году работа по «Объекту исследования 3» был приостановлен. А результаты исследования с июня 2007 года по декабрь 2008 года находятся по адресу: http://www.icarda.org/cac/files/slmr/ADB_TA_6357_SLMR_1st_Ann_Rep_2008_RUS.pdf

2.6 Kazakhstan: Activity 4. Study of the influence of various boundary conditions on water-salt balance in growing rice to save irrigation water and reduce salt accumulation

2.6.1 Introduction

63. One of the main factors determining fertility of irrigated soils in arid zone is its water-saline regime. Namely with breach of hydro-geological and hydro-chemical regime of the territory the main environmental costs of irrigation are connected. For timely finding of the beginning of deterioration of reclamation condition of irrigated lands and identification of their reasons and development of regulating methods of water-saline regime of soils and improvement of their reclamation condition the overall systematic complex study of soil processes is needed as well as regimes and other factors influencing on reclamation condition of irrigated lands.

2.6.2 Research aims

- to study of seasonal dynamics of salts in conditions of periodic flooding of soils in growing rice.

For this aim during the project work in the beginning and end of the season the saline content in soils has been identified and appropriate saline maps have been developed.

2.6.3 Materials and methods

2.6.3.1 Investigated site

64. The work was carried out on the territory of Company Ltd. «Kaptagay and K» in Shieli irrigation area. Geographical position, main factors of soil formation and other natural conditions of irrigated area are described in detail below.

65. The direct object of study included the rice-swamp soils which are spread on the investigated territory. They have been formed under conditions of excessive moistening associated with the specific conditions of rice cultivation (continuous flooding). The duration of continuous flooding of rice is 90-110 days depending on varieties of rice. During the period of vegetation of rice through the soil a large amount of water is filtered that causes severe fluctuation of the level of ground water - from 2.5 m at the beginning of irrigation to their merging with them with irrigation water. In normal work of collector-drainage network the ground water by autumn come down to the same depth. In their regime the seasonal cycles is settled. Described soils are characterized by 1.2-2.4% of humus. Humus soil profile is reverse

and much stretched. A significant amount of humus (about 1%) can be found at a depth of 1 m and below that is not typical for other soils.

66. All of them are underlying on depth 80-150 cm as supes or sand. They tend to increase small fractions (silt, less than 0,001 mm) at a depth of 20-40 cm Thus, the horizons of 20-40 cm, compared with higher-and lower horizons are heavier. Such regulation may depend either on the movement of thin particles from upper horizon, or clay soil (formation of silt particles in place), or from settling of fine fractions on plough surface when muddying. (Borovsky 1959).

67. In irrigated (rice) marsh soils water-physical properties vary greatly. Soil structure is destroyed - the value of dispersion factor according to N.A Kaczynski is 5-10 times higher than in similar grounds of virgin soil. As a result of compaction in the surface layers the unit weight increases (0.89-1.04 g cm⁻³ to 1.25-1.35 g cm⁻³) and fenestration is reduced (from 60-63% to 49-52%). Water permeability is dramatically reduced (filtration coefficient reduces from 0.07-0.20 to 0,02-0,04 m / d) (Karazhanov 1983).

68. After plowing arable layer of rice field consists of structural parts of various sizes. After flooding the field, it turns into a semi liquid mass - the mud, and not affected by tillage under tillage and tillage layer is more or less dense. When drying (after harvesting of rice) under tillage and tillage layers become compressed, forming a thick layer without any structure and their volume weight nearly equal, approaching an average to 1.5. Such soils after harvest of rice quickly dry up. Compaction of arable layer, equalizing of volume weight of arable under till and till layers create conditions in these soils for strong moisture evaporation, and in close bedding of highly mineralized groundwater and secondary salinity of soils.

69. As can be seen from the description of the basic properties, the rice-/swamp soil, according to nature, in ineffective work of collector-drainage networks are subject to secondary salinity. Therefore, in order to maintain the optimum salt regime of those soils the necessary condition, first of all is to maintain normal operation of collector-drainage network, timely repair works which support their compliance of the parameters with project standards.

2.6.3.2 Methodology

70. In carrying out of the work the quite frequent and well tested techniques in soil science have been used such as - profile method and the method of soil-regime observations. Profile method is a basis for all soil studies and requires compulsory study of soil from the surface to the depth of its layers gradually on genetic horizons up to the mother rocks and comparison of the studied properties or parameters of soil profile. Method accurately reflects the natural characteristics of vertical anisotropy of soil, development of soil formation process and soil regimes. Method of soil- regime observations is used for studying of the kinetics of the modern soil formation on the basis of measurements of different parameters, in our case, the content of salts in the same soil during long-term period (vegetation season, a year, several years) after specified time intervals.

71. Seasonal dynamics of salts was determined by conducting large-scale salt shootings (1:2000 scale) of experimental station (8-field of 4 crop rotation). During the time of the project three salt shootings have been conducted in the pilot area - spring-autumn and spring of the next year. According to the Guide for the large-scale soil survey in the Kazakh SSR (1979), each time 25 soil sections have been observed.

72. Preparation of water extracts from soils was conducted according to K.K Gedroits, pH, SO₃, NSO₃ were determined by potentiometric method, Cl and SO₄ - titration, Ca and Mg – by using atomic-absorption spectrometry, K and Na - with flame photometry.

73. After processing and systematization of field and laboratory data in a GIS environment with the use of computer program MapInfo, salt maps of experimental plot were developed, i.e. method of computer mapping of soils was used.

2.6.4 Results and discussion

74. As it can be seen from the map, content of salts in the soil in spring 2008, the major area of experimental plots (80.7% of the total area) are occupied by the medium and heavy saline soil (Table 12). And practically the whole territories, except for 4.4 ha of marsh and deep marsh soils occupy saline soils, salt on the top. This profile of salinity is a characteristic of secondary saline soils. As we can see, experimental plot was correctly chosen and is representative for the soils throughout the territories of Company Ltd. «Kaptagay and K» (see the object of activity 1).

75. To determine the seasonal changes in the content of salts in the soil of experimental plot, i.e the seasonal dynamics of salts in autumn 2008 at the experimental site, the repeated salt shooting was conducted and a map of soil salinity in the environment of GIS with the use of a computer program MapInfo Professional was done (Figure 16).

76. By comparing salinity maps of different periods (method of map analysis) it can be seen that during the vegetation season a certain de-salinity of soils took place. In the experimental station the nonsaline soils appeared, at 7.0 ha or 24.6% of the experimental plots area, the upper 50 cm of soil layer have completely become less saline. (Table 12). At the contour of saline (saline on top) soils a slight de-salinity of soils took place. The area of weak saline soils has increased to 9.0 ha, and area of average saline soil, on the contrary has decreased to 10.6 hectares. The contour of heavy saline soil, which occupied in the spring shooting 9.9 ha or 34.9% of the plot in fall shooting has not been detected, i.e. due to the process of de-salinity the heavy salinity soil moved to the category of less saline soils. Practically in all sections, the coefficient of seasonal accumulation of salts is less than a unit, i.e. during a season some de-salinity of soil took place. In general, the contour area of saline soils from the surface of saline soil as compared to the spring shooting period (24.0 hectares) has decreased to 11.5 ha and during the autumn shooting occupy only 12.5 ha.

77. Area of contour with marsh soils, saline horizon of which is located within 30-80 cm, during the vegetation season increased to 5.6 ha due to desalination (washing) of the upper 0-50 cm soil layer in the contour of saline soils, i.e. saline horizon of the soils has moved to the lower horizons. In this contour also in all cuts the coefficient of seasonal accumulation of salts is less than one. Here, the main area is occupied by average saline soils (5.6 ha), and heavy saline soils occupy only 0.7 ha.

78. Thus, we can say that for one growing season, some desalinization of soil occurred, heavy saline soils have transferred into average saline soils, and average saline soils – into low-saline etc. Despite this, it is seen from the map of soil salinity that the intensity of removal of salts from the root layer is insufficient. This is confirmed by the fact that during the vegetation period the soils have been desalinized only on 7.0 ha or on 24.6% of the plot. On the rest area the soil remained saline in various rates of salinity.

79. From the analysis of analytical data and maps of soil salinity we can see that for the autumn-spring period 2008-09 there have been some restoration of salts. For example, the area of desalinized soils has reduced to 0.7 ha and the area of weak saline soil and average saline soils has increased respectively to 0.9 and 0.2 ha. Also the areas of saline soil have changed. Area of saline weakly saline soils decreased to 2.6 ha, and area of saline average salty soils has increased to 2.2 ha.

2.6.5 Conclusions

80. As a result of the study it was determined that the salt regime in periodically flooded soils consists of a summer washing cycle (during the flooding of fields) and fall cycle of restoration of salinity (after irrigation period). Restoration of the original content of salts in the unfavorable environment of reclamation, which is unfortunately observed on the experimental plot, can occur less than year after harvesting of rice.

81. This situation, first of all, is connected with the deterioration of the collector-drainage network, with silt, the inconsistency of their parameters with the project ones and rise of groundwater levels (GWL) (Figure 2).

82. We know that deeper is the groundwater, the faster is desalinization of upper root layer. Currently, when the shortages of fresh water take place, anti-filtration works in rice plots and also colmatage of main canals and other activities to combat unproductive losses of irrigation water are almost forgotten.

2.6.6 Proposals for Further Research

83. During evaluation of the soil-reclamation of irrigated lands the key indicators of parameters of soil fertility serve as main indicators of the level of meeting the needs of crops in the formation of the harvest. In real production conditions the level of these indicators of soil

fertility is always connected with a risk of deviation from their optimal values, i.e. there is a real risk of loss of crops. The value of this loss of crops (i.e., risk) is primarily connected with the quality and timeliness of accurate scientific information on soil-melioration status of the irrigated area. That is, the cost of scientific information, along with other costs of improving the reclamation of soil becomes the indicator of economic efficiency of techniques of sustainable land resources management.

84. In this regard, as a **continuation of this project**, we propose to implement the best practices of scientific research done at international level into practice of soil studies. At present, unfortunately, because of insufficient funding for research, there is a problem of insufficient and slow implementation of such methods. One of such directions is the introduction of land-reclamation and hydro-geological studies with computer mapping of soils, method of remote sensing of land based on geographic information system. The method is based on the use of special software for collecting, storing, processing and visualization of space-coordinated data, i.e. establishment of soil-reclamation geo- information system (GIS) of irrigated area.

85. The available map materials have been developed by using traditional methods using only topographical basis and do not meet modern requirements. Most of them are now significantly out of date. The data collection system often did not have a clear structure, temporal and spatial referencing of data provided little qualitative (eg, binding of soil sections based on geographic identifiers, etc.), which makes very difficult their automated processing. The principal feature of GIS is that they allow not only to optimize the storage and processing of research results, but also significantly improve the information and scientific value of primary data. Therefore, we propose the establishment of a pilot geo-information system in Shieli area of irrigation. At the same time, the GIS will be adapted to address soil-reclamation, hydro-geological and environmental problems of irrigated area. In the frame of this project an electronic database will be created that includes spatial-coordinated main data on main reclamation groups of soils, their main parameters of fertility, hydro-geological and environmental indices of irrigated area. Moreover, similar activities have been started due to the ICARDA Project «Sustainable management of irrigated land resources in the Republic of Kazakhstan».

86. In the future, this GIS will be used for conducting continuous monitoring of soil-reclamation, hydro-geological and environmental conditions of Shieli area of irrigation, and with some additions could be introduced in other irrigated areas of arid zones in Kazakhstan and Central Asia countries.



Figure 16. Research on land degradation in Kaptagay farmer holding.

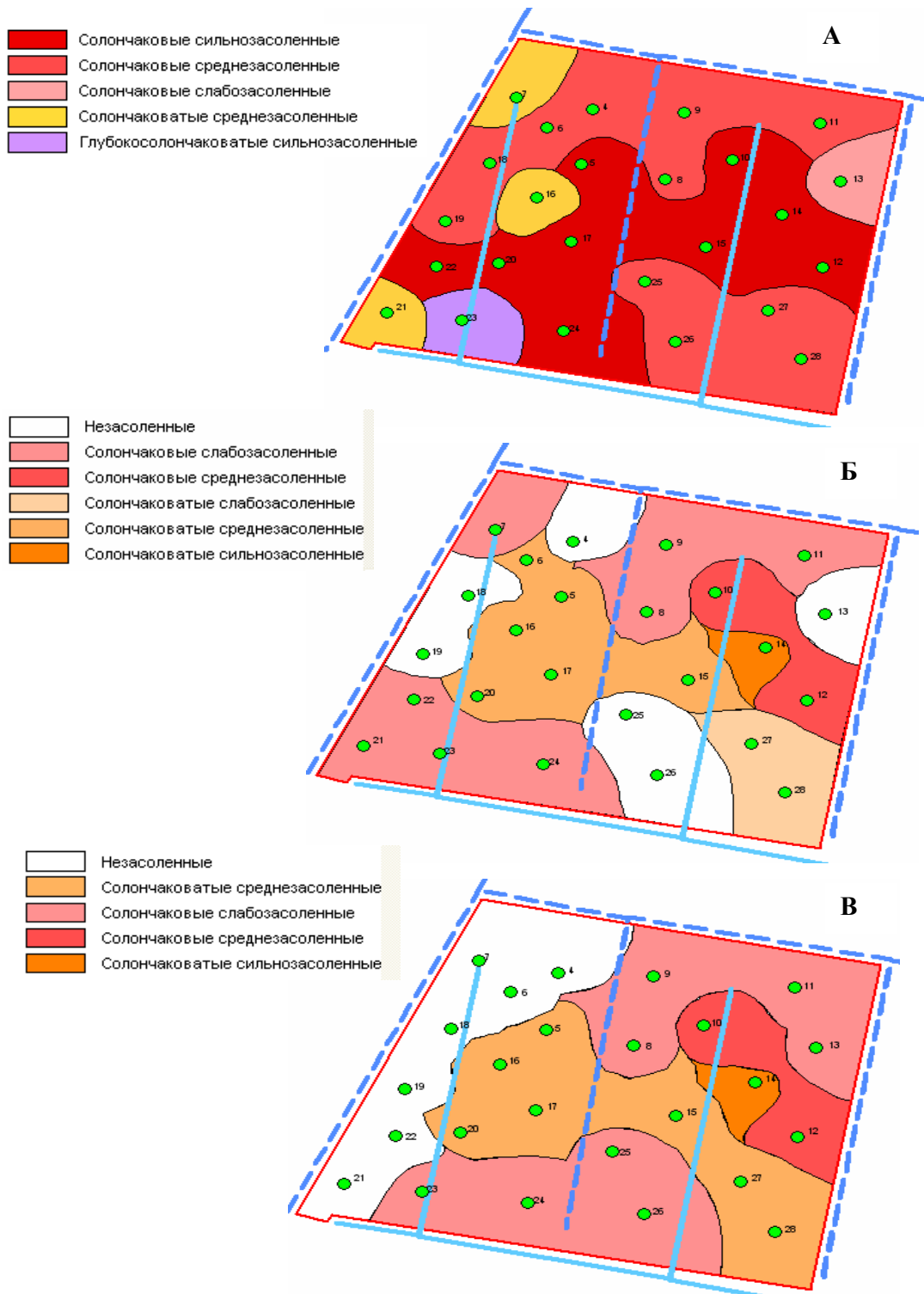


Figure 17. Soil salinity map on experimental site: A – in spring, B – in autumn 2008 and C – in spring 2009.

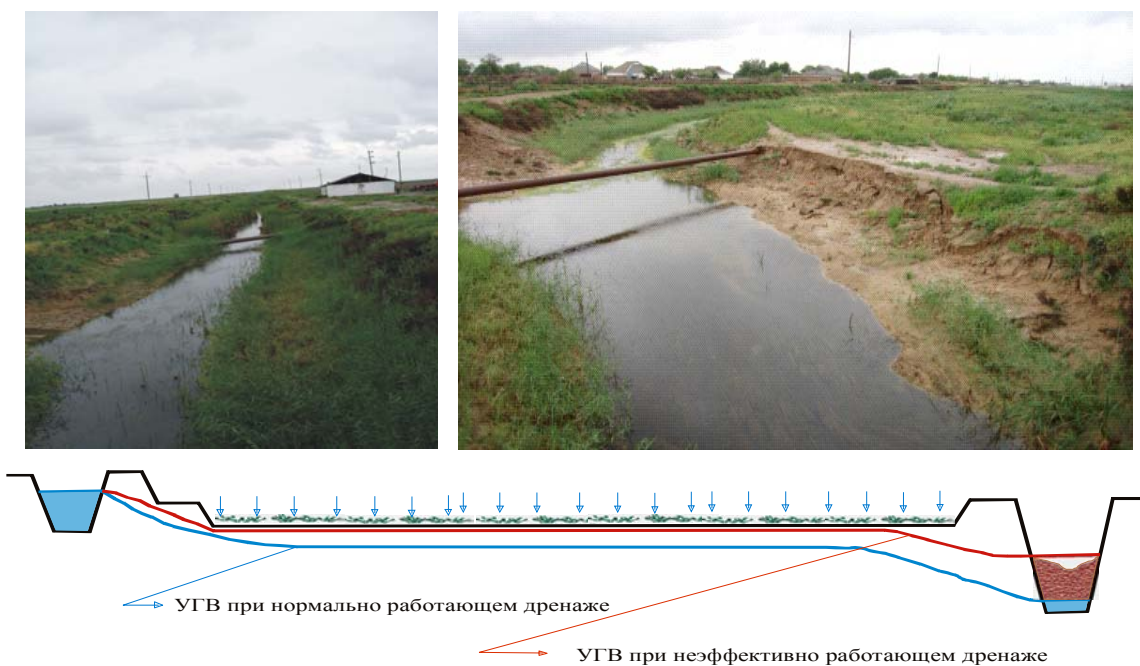


Figure 18. Current conditions of the drainage net and scheme increasing ground water level under the condition of inefficiently working drainage.

Table 12. Soil salinity in spring 2008, autumn 2008 and spring 2009

Soil type	Spring 2008	Autumn 2008	Difference, (+,-)	Spring 2009	Difference, (+,-)
Non-saline	-	7	7	6,3	-0,7
Solonchak slightly saline (0-30 cm)	1.1	10.1	9	11	0.9
Solonchak moderately saline (0-30 cm)	13	2.4	-10.6	2.6	0.2
Solonchak highly saline (0-30 cm)	9.9	-	-9.9	-	-
Slightly saline soils within the layer of 30-50 cm.	3.3	2.6	-0.7	-	-2.6
Moderately saline soils within the layer of 30-50 cm.	-	5.6	5.6	7.8	2.2
Highly saline soils within the layer of 30-50 cm	-	0.7	0.7	0.7	-
Moderately saline soils within the layer of 50-80 cm	1.1	-	-1.1	-	-
Total:	28.4	28.4		28.4	

2.7 Kazakhstan: Activity 5. Study of raised-bed rice planting, evaluation of the performance of new rice cultivars developed in Kazakhstan and the Russian Federation and application of growth stimulators on rice²

2.7.1 Introduction

87. The territory of the Kyzylorda province covers a total area of 228.300 sq. km (about 8.6% of the total Kazakhstan area). Regulating of the Syr-Darya river flow, sharp reduction in the water area of the Aral Sea, climate change towards desertification and increase of continentality result in soil degradation, increase in salinity of irrigation water, sedimentation of the salts from the naked bottom of the Aral Sea. Shortage of irrigation water has resulted in sharp declines in stream flows into the Aral Sea and irrevocable water shrinkage of the delta of the Syr-Darya River and to desertification of territories. Processes of secondary soil salinization were highly developed on a greater part of the irrigated lands, resulted in soil fertility decline.

88. At the same time the agriculture and, in particular, rice growing industry is one of bases of economy of Kyzylorda province subjected to the Aral ecological crisis where farmers rely heavily on this crop for their livelihood. The population of area made 632.6 thousand persons, with nearly 40% of the population (247.8 thousands persons) living in the countryside.

89. Existing technologies of rice growing in region are not rational through technical and financial point of view. There are 13 pre-sowing technological operations with minimum 7 are recommended to implement under traditional rice cultivation. Weed control is very poor. Soil fertility losses are high. Costs of fuels and lubricants and spare parts of the agricultural machinery are high.

90. Therefore there is need to introduce the water and recourse saving technologies in rice production on the base of raised bed and minimum –zero tillage technologies with short and periodic irrigations in order to make rice growing sustainable.

91. Under adoption of these technologies, 30-40 % of irrigation water could be saved which will substantially improve the ameliorative conditions of the irrigated lands and ecological conditions of the region. The seed rate and fuel costs could be reduced by half thereby the farmer costs will decrease and agricultural profitability will rise.

92. Rice is an important crop generally cultivated in irrigated lands in the Kyzylorda region, Kazakhstan, where large irrigated area is affected by secondary salinization in a various extent; over 80 % of rice crop area is occupied with rice cultivars released 20-30 years ago. These varieties (Marjon and Kuban 3) are mostly adapted to local soil-climatic conditions but are

² Выполняется КазНИИ риса (отв. исполнитель д-р Карлиханов Т.К.) и отчет будет представлен отдельно.

susceptible to biotic stresses. These rice varieties don't meet modern requirements, especially; they are not resistant to fungous diseases. Therefore there is shortage of the rice cultivars in Kyzylorda region which meet the international standards of grain quality, require less water, tolerant to salinity and have high genetic yields potential under specific conditions of the Kazakhstan Pri-Aral.

93. For the last 5 years Kazakhstan Research Institute of Rice production introduced and submitted several new rice cultivars to State Varietal Testing Committee.

94. In Kyzylorda farmers grow cultivars differing in maturity group, early group matures in 85-90 days (variety Aru), and cultivars Aral 202, Togusken 1 and Madina maturing in 110-120 days. Since week multiplication of rice seeds for distribution to farmers and propagation, these varieties were not disseminated in larger scale. As a result some large rice producing farms under support of Kyzylorda governance which provided them the interest-free credit for purchase of seeds have started delivering of seeds of cultivars released in Russian Federation. In total, 10 rice cultivars have been brought from Russian Federation to cultivate in Kyzylorda province.

95. But there is lack information on most appropriate varieties for farmers from economic and ecological points of view i.e. resources and water-saving. Therefore, the present study was taken up to screen short duration, less lodged Kazakhstan and Russian rice cultivars most adapted for local conditions and to demonstrate their advantages among farmers at the Kaptagay farm of Shieli district of Kyzylorda province.

2.7.2 Research objectives

96. The main purpose was to enhance the competitiveness and stability of an agricultural production in irrigated agriculture of Kyzylorda province via development and introduction of resource conservation and water-saving technologies, such as cultivation of rice on raised beds, minimum and zero tillage under rice cultivation.

2.7.3 Project tasks

- 1) Development and adaptation of resource conservation and water-saving technologies of cultivation of rice, on the basis of minimum tillage and raised beds technologies under irrigated local conditions;
- 2) Ecological test of perspective rice varieties of the Kazakhstan and Russian selection with the purpose of screening of the most adapted to the local conditions and demonstrations of their advantages amongst other farmers.
- 3) Demonstration of rice cultivation and advantages of minimum, zero till and raised bed technologies in compare with traditional method of cultivation of rice by organization

of Farmer Days in 2008 and 2009 in Incorporated Open Company (IOC) "Kaptagai" in Kyzylorda province.

2.7.4 Materials and methods



Figure 19. Overview of the Kyzylorda region

97. Experimental trials were conducted in IOC "Kaptagai" in Shieli region of Kyzylorda province in 2008-2009. The Shieli region occupies 11 % of the agricultural lands in Kyzylorda province, including 15 % of irrigated arable lands. Total population is 78.2 thousand persons, including 49.2 thousand ones in the rural area.

Table 13. Land use in Kyzylorda province, thousand hectares

Regions of Kyzylorda province	Land area	Agricultural lands	Including					
			Arable land	Long-term plantings	Fallow lands	Hay-makings	Pastures	
							Total	Irrigated
Total provincial area	24899.6	12923.6	150.448	2.8	116.452	116.5	12538.4	9193.0
Shieli region	3426.9	1432.0	23.796	0.5	22.704	11.3	1374.7	1148.0

2.7.4.1 Methodology

2.7.4.2 Minimum-zero tillage for rice crop

98. Experiment with application of the multi-crop Indian zero tillage/raised bed planting machine was established in 2008-2009.

99. The predecessor crop was rice. Fertilizers in the form of Sulfate Ammonium and Ammonium phosphate were applied at the rate of 300 kg ha⁻¹ and 100 kg ha⁻¹, respectively, just before sowing. Rice sowing and flooding were implemented in optimum time, i.e. 13-15 May 2009. Weeding was done with herbicide named “Gulliver” at the rate of 25 g ha⁻¹ in full germination stage.

100. Experiment with zero till technology in 2008 was conducted with two treatments and three replications on the check (basin) with the total area of 2 hectares. Subplots with area of 200 m² were established with the following treatments:

- Conventional seed broadcasting with local seeder (Model: SZN-3.6) after implementation of the soil tillage under standard rice cultivation technology
- No tillage, with special seeder by using disk furrow openers.

101. Experiment on study of zero till (direct planting) and the minimum tillage technology of cultivation of rice was established in 2009, together with the control (conventional technology) with three treatments and three replications. Subplots with the monitoring area of 200 m² were established by a systematic method with the following treatments:

1. Traditional planting method (control) - plowing with mould-board + land leveling + disking + harrowing in 2 traces + rolling with ringed rollers + planting at the seed rate of 250 kg ha⁻¹ - the control;
2. Reduced tillage - disking + harrowing + rolling with ringed rollers + planting at the seed rate of 250 kg ha⁻¹;
3. Zero till technology - direct planting by a special seeder with disk openers (manufactured in India) on stubble rice at the seed rate of 50 kg ha⁻¹.

2.7.4.3 Raised bed planting

102. Field experiments were established on the predecessor - ameliorative field (2008) or after rice (2009). Just before planting the following farming practices were applied: plowing to the depth of 22-24 cm, land leveling (soil grinding), application of fertilizers (sulfate of ammonium - 300 kg ha⁻¹, ammonium phosphate – 100 kg ha⁻¹), two-multiple harrowing, rolling by grinded rolls followed by planting and flooding. During full germination crops were treated by herbicide Gulliver in a doze of 25 g per ha⁻¹.

103. Experimental trials in 2008 were conducted on the check-basin with area of 2.5 ha by using of specialized multi-crop seeder for rice planting on the raised beds, manufactured in India.

104. The following treatments were established:

1. Traditional (standard). Broadcasting planting method at the rate of 250 kg ha⁻¹ –control
2. Raised bed planting – wide of beds is 90 cm, height of beds is 18-20 cm, inter-row space is 20 cm, and the seed rate is 90 kg ha⁻¹.
3. The same as in treatment 2 but the seed rate is 110 kg ha⁻¹.
4. The same as in treatment 2 but the seed rate is 130 kg ha⁻¹.
5. The same as in treatment 2 but the seed rate is 150 kg ha⁻¹.

105. Areas of subplots under treatment 1, 2, 3, 4, 5 were 825 m², 1155 m², 1980 m², 2640 m² and 1650 m², respectively. Monitoring area was 200 m².

106. In 2009 3 seeding rates along with control were studied over two varieties of rice: Marjon (Kazakhstan) and Yantar (Russia). It was assumed to test 2 seeding rates – 3.0 and 4.5 million seeds ha⁻¹, which corresponds to, approximately, 100 and 150 kg ha⁻¹, respectively. However the available two complete sets of the disks of the given seeder have allowed sowing only at the seed rates of 40 and 60 kg ha⁻¹ that corresponds approximately to 1.2 and 1.8 million seeds ha⁻¹. The norm of seeding in control was 7.5 million seeds ha⁻¹ under seed broadcasting method.

107. Experiment was conducted with three treatments and three replications with the total area of 4.8 hectares. Subplots area was 0.25 ha with the following treatments:

1. Traditional (standard). Broadcasting planting method with the seeder (Model:SZN-3.6) at the rate of 7.5 million seeds ha⁻¹ –control
2. Raised bed planting – wide of beds is 70 cm. heights of beds is 16-18 cm. inter-row space is 20 cm. and the planting rate is 1.2 million seeds ha⁻¹.
3. The same as in treatment 2 but the seeding rate is 1.8 million seeds ha⁻¹.

2.7.4.4 Irrigation regime –short flooding:

- Before occurrence of shoots = depth of water at the top of beds no more than 3-5 cm;
- Then the depth of water raises as the plants height increases up to 10-12 cm;
- During bushing stage = depth of water decreases up to minimum of 3-5 cm;
- During flowering stage = the water depth raises up to 15-20 cm;
- From the moment of dairy-wax ripeness stage= the water depth gradually decreases;
- In the stage of wax ripeness = the water delivery stops.

2.7.4.5 Ecological test of varieties of rice of the Kazakhstan and Russian selection

108. The predecessor is 2 years standing Lucerne. The farming practices are traditional for the given zone of cultivation of rice.

109. Just before rice planting the following farming practices were applied: plowing to the depth of 22-24 cm, land leveling (soil grinding), application of fertilizers (sulfate of ammonium

- 300 kg ha⁻¹, ammonium phosphate – 100 kg ha⁻¹), two-multiple harrowing “ZIGZAG”, rolling by grinded rolls followed by planting and flooding (10-12 May).

110. Eight rice cultivars, including four Kazakhstan (Marjon, Aral 202, Aru and Togusken 1) and four Russian (Novator, Lider, Rapan and Yantar) were tested with three replication at the competitive nursery.

111. The subplot area is 50 m² (5 m × 10 m) with three replications.

112. Subplots were placed in one tire; protective paths between subplots were 0.4 m. Norm of seeding was assigned at the rate of 7.5 million grains ha⁻¹ in view of laboratory germinating capacity and cleanliness of seeds.

113. During full germination crops were treated by herbicide Gulliver in a doze of 25 g ha⁻¹.

2.7.4.6 Phenological observations

1. Monitoring over the crop growth and development was conducted from the time of the starting (10%) and full completion (75%) of the different stages during crop season.
2. Observations over plant density, germination and infestation were conducted after germination and before harvesting over all treatments and replication at different monitoring subplots (0.25 m²).
3. The soil samples were taken at different soil depths of 0-20 and 20-40 cm in order to determine the soil fertility and soil salinity before planting and after harvesting of rice.
4. To assess the crop yields and biometric analyses 10-20 plants were monitored.
5. Yield data were analyzed using the statistical methods.

2.7.5 Results and discussion

2.7.5.1 Minimum-zero tillage for rice cultivation

114. During the crop season phenological observations included monitoring of the plant density after emergence and before rice harvesting and weeds such as a reed (*Phragmites communis*), *Bolboschoenus* and *Echinochloa* (Table 14).

Table 14. Plant density of rice and of weeds as affected by various seed rates, 2008

Treatments	Quantity of plants of rice and weeds. No m ⁻²				Seed germinating, %	
	Rice	Weeds				
		Phragmites communis	Bolboschoenus	Echinochloa		Total
Ploughing by mould board plough to the depth of 22-24 cm + disking + harrowing + rolling + Broadcasting planting method with the seeder (Model:SZN-3.6) at the seed rate 250 kg ha ⁻¹ (control)	212	-	-	4	4	22.0
Row seeding of rice in undisturbed soil by a special seeder with application of disk furrow openers at the seed rate of 150 kg ha ⁻¹ (RS)	164	19	2	8	29	44.0
LSD _{at p=0.05}	7.95					

The note: calculation of plants was done before application of Gulliver herbicide

115. The plant density on the raised bed plot (164 plants m⁻²) was less than that under control (212 plants m⁻²) by 1.32 times, while the seeding rate on raised beds was less by 1.7 times. Therefore, germination of plant seeds under new planting method (44%) was by 16.0% higher than under control (28.0%).

116. The quantity of weeds before herbicide application in RS treatment was 29 pieces m⁻², while that under control was 4 pieces m⁻². Among weeds, *Phragmites communis* and *Echinochloa* were predominant and to less extent *Bolboschoenus*. Similar results have been received in 2009.

117. Weed population was little affected by seed rate. Results revealed that Zero till enhanced the seed germination (Table 15). So, seeding rates under zero till less than that under control and minimum tillage by 5 times but plant density at zero till was less than under control and minimum tillage by 2.3 and 3.3 times, respectively. Positive influence of zero and minimal tillage on seed germination in comparison with traditional one can be explained by formation of large clods, which impact water flow rate under traditional tillage, while minimum and zero-till create fine-grained textured soil and large lumps are practically absent.

Table 15. Plant density of rice and of weeds as affected by various tillage technologies. 2009

Treatments	Quantity of plants of rice and weeds. pieces/m ²					Seed germinating. %
	Rice	Weeds				
		Phragmites communis	Bolboschoenus	Echinochloa	Total	
Conventional planting -Control	114.7	14.7	1.3	-	16.0	15.3
Minimum tillage	164.0	14.7	-	-	14.7	21.9
Zero tillage	61.3	30.7	-	-	30.7	40.9
LSD _{at p=0.05}	8.15					

118. Distinctions between control and minimum tillage on weed (*Phragmites communis*) density were not statistically significant at 5% level while Zero till enhanced almost by two times weed population so weeds could be significantly reduced if the pre-emergence herbicides molecules such as “Pendimethylene”, followed by post-emergence molecule “Gulliver” becomes available. It will also obviate the need for continuous submergence resulting in further saving of the fresh irrigation water supplies.

119. Crop attributes data presented in the Table 16 revealed that plant density under zero-till (156 plants m⁻²) did not much differ from that under control (200 plants m⁻²) and Zero-Till produced almost the same yield (4.76 t ha⁻¹) as control treatment (4.93 t ha⁻¹) (Table 16).

Table 16. Table 4 Plant density and grain yield before harvesting as affected by planting technologies. 2008

Treatments	Density of plants before harvesting		Yields	
	Plants m ⁻²	Survival rate of plants, %	t ha ⁻¹	%
Conventional planting –Control (250 kg ha ⁻¹)	200	94.3	4.93	100.0
Zero tillage	156	95.1	4.76	96.6
LSD _{at p=0.05}			0.39	

2.7.5.2 Raised bed planting system

120. In 2008 maximum planting density was observed under raised bed planting technology at the seed rate of 110 kg ha⁻¹ (126 plants m⁻²) and 130 kg ha⁻¹ (130.2 plants m⁻²), while that under seed rate of 90 kg ha⁻¹ was 70.7 plants m⁻². Distinctions between variants on density of standing of plants are statistically significant at the level of 5 % and 1 % ($F_{\text{fact.}} = 10.9550$, $F_{\text{tab.}} = 2.69$ and 4.02 respectively) (Table 17).

Table 17. Plant density of rice and weeds as affected by different seed rates on the raised beds. 2008

Treatments	Quantity of plants of rice and weeds, pieces m ⁻²					Seed germination . %
	Rice	Weeds				
		Phragmites communis	Bolboschoenus	Echinochloa	Total	
Broadcasting planting method at the seed rate 250 kg ha ⁻¹ (control) (7.6 million seeds)	178.2	8.0	-	13.3	21.3	23.4
Raised bed planting at the seed rate of 90 kg ha ⁻¹ (2.7 million seeds)	70.7	-	-	13.3	13.3	26.1
Raised bed planting at the seed rate of 110 kg ha ⁻¹ (3.3 million seeds)	126.2	-	-	11.1	11.1	38.2
Raised bed planting at the seed rate of 130 kg ha ⁻¹ (3.9 million seeds)	130.2	28.9	1.8	20.9	51.6	33.4
Raised bed planting at the seed rate of 150 kg ha ⁻¹ (4.5 million seeds)	79.1	4.9	-	104.9	109.8	35.4
LSD at p=0.05	37.86					

121. The plant density under control was 178.2 plants m⁻². Maximum seed germination was observed under treatments with seed rate of 110 kg ha⁻¹ (38.2%) and 150 kg ha⁻¹ (33.4%) against control – 23.4%. Relatively low germination was observed on treatments with planting density of 90 kg ha⁻¹ (26.1%).

122. Minimum quantity of weeds were observed under planting rates of 90 kg ha⁻¹ (13.3 pieces m⁻²) and 110 kg ha⁻¹ (11.1 pieces m⁻²). Maximum number was observed on treatment at the seed rate of 150 kg ha⁻¹ (109.8 pieces m⁻²).

123. At the same time plant density varied proportionally to the increase of planting seed rates both after germination and before harvest. Distinctions between plant density under control and raised bed at 150 kg ha⁻¹ were not statistically significant at the level of 5 % (Table 18). Although the seed germination under all raised bed treatments was by 10.0-14.5% higher than that under control but only raised beds with seed rate of 90 kg ha⁻¹ demonstrated higher survival rate (43.2%) than control (41.9%) and other seed rates treatments reduced survival rates by 4.2-8.6%. Raised bed technology did not significantly affected on rice yields and yields were at the range of 4.90-5.27 t ha⁻¹. Only raised bed treatment with the seeding rate of 90 kg ha⁻¹ slightly reduced crop yield by 0.37 t ha⁻¹.

Table 18. Plant density and yields of rice as affected by different seed rates on the raised beds. 2008.

Treatments	Quantity of plants of rice, pieces m ⁻²		Survival rate of plants, %	The length of crop season, days	Yields, t ha ⁻¹
	After emergence	Before harvesting			
Broadcasting planting method at the seed rate 250 kg ha ⁻¹ (control) (7.6 million seeds)	178.2	74.7	41.9	109	5.27
Raised bed planting at the seed rate of 90 kg ha ⁻¹ (2.7 million Seeds)	70.7	30.7	43.2	114	4.90
Raised bed planting at the seed rate of 110 kg ha ⁻¹ (3.3 million seeds)	126.2	42.0	33.3	112	5.20
Raised bed planting at the seed rate of 130 kg ha ⁻¹ (3.9 million seeds)	130.2	46.7	35.9	110	5.25
Raised bed planting at the seed rate of 150 kg ha ⁻¹ (4.5 million seeds)	159.1	60.0	37.7	109	5.16
LSD at p=0.05	37.86	11.61			0.46

124. Weak crop stands in 2009 on raised beds could be associated with long protracted and cold spring and rainy season at the late May and early June, which has led to postponing of germination of the seeds at the depth of 3.4 cm and high mortality rates of young seedlings. Despite of this, there is clear the effect of the seed rate on plant population. The plant density under the seed rate of 1.2 million seeds ha⁻¹ was minimum (8.7 and 13.3 pieces m⁻²) or by 3.0 and 1.9 times lower than that under the seed rate of 1.8 million seeds ha⁻¹ (26.0 and 25.3 pieces m⁻²). At the same time Marjon variety produced 170.0 pieces m⁻² while Yantar only 105.3 pieces m⁻². There is not effect of the seed rate under raised beds planting on the rate of weed infestation (Table 19).

125. However, lower plant density on raised beds as show experiences of 2008 further can be compensated by increase in the quantity of productive stalks, plant survival rate, and decrease in lodging of plants. Therefore final conclusions on efficiency of rice planting on raised beds will be drawn after conducting of biometric analysis and yield data collection during ripening stage in fall 2009.

Table 19. Plant density and yields of rice as affected by different seed rates on the raised beds, 2009

Treatments		Quantity of plants of rice and weeds, pieces m ⁻²				
Variety and planting technology	Seeding rates, million ha ⁻¹	Rice	Weeds			
			Phragmites communis	Bolboschoenus	Echinochloa	Total
Marjon- Raised beds	1.2	8.7	0.0	14.0	0.7	14.7
Marjon - Raised beds	1.8	26.0	0.0	6.0	4.7	10.7
Marjon - broadcasting - control	7.5	170.0	0.0	1.0	2.0	2.1
Ayntar- Raised beds	1.2	13.3	0.0	11.3	18.7	30.0
Ayntar - Raised beds	1.8	25.3	1.3	2.0	2.7	6.0
Ayntar - broadcasting - control	7.5	105.3	8.0	6.7	6.7	13.4

2.7.5.3 Ecological testing of Kazakhstan and Russian rice cultivars

126. Crop data collection revealed that seed germination of the tested rice varieties were very poor and ranged from 0.4 to 13.7% in 2008. Relatively higher seed germination was observed under Kazakhstan varieties such as Marjon (13.7%) and Aral 2002 (11.9%) and Russian cultivars such as Yantar and Lider (8.8%). Low field germinating capacity seeds are crop varietal characteristics which shows the stability of the cultivar to the deep depth of water maintained at the check (basin) in order to struggle against weeds during plant emergence.

127. In 2009 similar results have been received, Marjon, Aral 202 and Lider have been found as the best varieties, but due to crops have been placed on higher place of the check, seeds germinating capacity was noticeably higher (Table 20).

Table 20. Plant density of rice cultivars during full germination stage.

Entry	Origin	Plant density of rice. 2008		Plant density of rice. 2009	
		Plants m ⁻²	% seed germinations	Plants m ⁻²	% seed germination
Marjon– St.	Kazakhstan	103	13.7	158	21.1
Aral 202	Kazakhstan	89	11.9	136	18.1
Ary	Kazakhstan	30	4.0	108	14.4
Togusken 1	Kazakhstan	3	0.4	86	11.4
Novator	Russia	10	1.3	117	15.6
Lider	Russia	65	8.7	164	21.9
Rapan	Russia	40	5.3	71	9.5
Yantar	Russia	66	8.8	115	15.3

128. In 2008, the maximum rice yields (5.1-5.2 t ha⁻¹) were recorded under moderate mature Russian varieties named Lider and Yantar, followed by moderate mature Kazakh varieties Aral 2002 (4.9 t ha⁻¹), Marjon (4.85 t ha⁻¹), early mature Kazakh variety Aru (3.65 t ha⁻¹), moderate mature Russian variety Rapan and early mature Novator (3.45 t ha⁻¹) (Table 21).

Table 21. Rice cultivars yields in ecological test of 2008

Cultivar	Origin	Yield, t ha ⁻¹
Aru- Early ripening	Kazakhstan	3.65
Novator- Early ripening	Russia	3.45
Marjon (standard) –Moderate ripening	Kazakhstan	4.85
Aral 202 - Moderate ripening	Kazakhstan	4.9
Lider- Moderate ripening	Russia	5.2
Yantar - Moderate ripening	Russia	5.1
Rapan - Moderate ripening	Russia	3.45
LSD _{at p=0.05}		0.15

2.7.6 Conclusions

129. Direct dry seeding of rice with zero till enhanced rice seed germination (40.9 %) by 1.9-2.7 times in comparison with minimal and traditional technology. Seed germination under minimum tillage (21.9 %) was higher by 1.4 times in comparison with conventional tillage (15.3 %).

130. The death rate (losses of plants) at zero till was 4.9 %, while that under control was 5.6 % under number of survived plants of 156 and 200 plants m⁻², respectively. Despite of the lower norm of seeding (100 kg ha⁻¹) Zero Till treatment had a 44.0 plants m⁻² higher plant density and similar to control crop yields.

131. Maximum plant density was observed under raised bed planting at the seed rate of 150 kg ha⁻¹ after germination and before harvesting 159.1 and 60.0 plants m⁻² accordingly while that under control (250 kg ha⁻¹) was 178.2-74.7 plants m⁻². Seed germination was higher under raised bed planting over control by 2.7-14.5 % and maximum survival rate (43.2%) was found at the rate of 90 kg ha⁻¹ as compare with control (41.9%). Other seeding rates had a 4.4-8.6% lower survival rates in comparison with control.

132. There were not significant differences amongst rice yields obtained under different tillage technologies (Zero Till, Raised beds, minimum tillage) and control. Crop yields were in the range of 4.90-5.27 t ha⁻¹. Seed savings ranged from 100 to 160 kg ha⁻¹ and irrigation rates were reduced by 4-6 thousands m³ per ha.

133. Only 2 Russian varieties (Lider and Yantar) produced the higher yields than new released Kazakhstan variety– Aral 202.

2.8 Kazakhstan: Activity 6. Calibration and use of optical sensor on evaluation of vegetation cover (Greenseeker) to control the dynamics of growth and development of crops in time and space, comparing the methods of cultivation of agricultural crops, selected in research of IUUZR and effective management of nitrogen

2.8.1 Introduction

134. Alongside with soil and climatic conditions the fertilizer application system is a major factor of shaping the size and quality of crops. There are different methods for calculating the doses of applied fertilizers - on the charts of availability of major components of soil nutrition in soils, the forecasted harvest, the planned increase in yield, etc. These methods require analysis of soils, plants for composition of nutrient substances. In addition to these methods now the remote methods (space, land surface) are used to determine the needs of plants in fertilizers. One of them is the use of optical sensor "Greenseeker", kindly donated to Kazakhstan by «International Center for Agricultural Research in the Dry Areas - ICARDA».

2.8.2 Research aims

135. Calibration and use of optical sensor «Greenseeker» to assess the dynamics of growth and development of winter wheat and effective management of availability of nitrogen in soils and plants.

2.8.3 Materials and methods

2.8.3.1 The research site

136. The research site is located in foothill zone of Zaili Alatau in Karasai district of Almaty region.

2.8.3.2 Methodology

137. In autumn 2008, due to lack of own experimental base we were unable to conduct the experiments with winter wheat with application of different doses of nitrogen. Therefore, for the development of the technology of using «Green Seeker» and monitoring over the dynamics of value NDVI, study of NDVI dependence on different doses of nitrogen applied in the form of spring feeding on the fields of experimental farm of Kazakh RI of crop production and land cultivation an experiment on winter wheat crops with the following experiment scheme was conducted:

138. Control, N0; N30; N60; N120. Repeated experiment 3-times. The size of the plots - 5 m². Date of feeding is 2 April. Prior to control date of submitting final report 6 measurements of

NDVI were made. The measurements were carried out every 15 days. Measurements of NDVI value were conducted in accordance with the methodology guidance to sensor.

2.8.4 Results and discussion

139. As it can be seen from the obtained data in Figure 20 the NDVI value is steadily increasing in doses of nitrogen 30 and 90 kg ha⁻¹ of D.V, but in other doses, the value of NDVI is subject to certain fluctuations. The maximum value in all doses is observed in observation period held on 26 May, and by the 5th period of observing a gradual decline begins, most likely associated with the beginning of ripening phase of wheat.

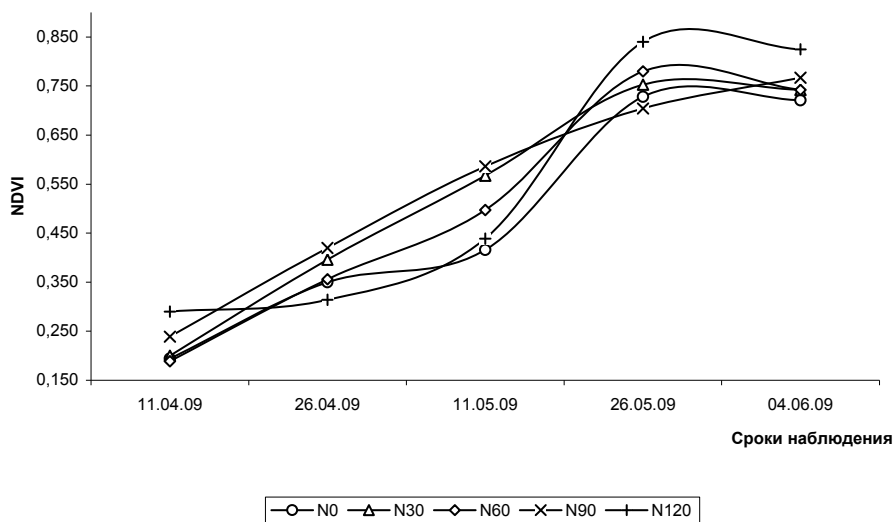


Figure 20. Dynamics of the NDVI values under different nitrogen rates.

140. For more details, please see also Final report - Part I.

2.9 Kazakhstan: Activity 7. Evaluation of the performance of different trees, shrubs, grasses and fodder crops in submontane plains, sand massifs, and sands in Abylay³

2.9.1 Introduction

141. One of the problems of livestock management in Kazakhstan is fodder production which constitutes 30-70% of the cost for the livestock products. Therefore it is important to use the cheapest fodder crops in order to produce more ecologically clean and cheap livestock products. One of the sources for cheap fodder crops is natural pasturelands. Pasturelands of Kazakhstan occupy 187 million ha or 67% of the total country area, with 124 million ha spread across the arid zone.

142. Use of the pasturelands is especially important for the arid zones with the extreme and unstable ecological factors that lead to the pasturelands low productivity as well as its drastic seasonal and annual fluctuations. Soils of pasturelands have low degree of drainage and naturally low level of fertility that does not provide necessary buffer for the anthropological and technological stresses.

143. It is generally known that economic value of pasturelands significantly depends on the diversity of the plant communities that supply animals with feed as well as contribute to the soil formation processes and act as biological mean for preventing pasture land degradation and desertification.

144. Therefore, current development of the livestock production within the desert zones along with other objectives pursues ecological goals such as conservation of the plant diversity, prevention of the soil and plant cover degradation. The effectiveness of the rangeland management depends on the correct assessment of the dynamic processes of yield formation under the condition of annually fluctuating agro-climatic factors of the desert area. It is very important to determine the most productive and draught resistant fodder crop combinations, types of planted pastures as well as alternative and perspective potentials of the fauna – tasks that were developed within the framework of the SLMR Project (rangeland management and fodder production component) of ICARDA.

2.9.2 Purpose

145. The purpose of this project is the development of the pastureland management and fodder production systems within the farmer holding situated in desert area of the Jambul province, Republic of Kazakhstan.

³ Заключительный отчет по участку Абылай будет представлен отдельно координатором участка д-ром Сейкаримовым А.

146. Implementation of the following tasks were planned:

- Selection and description of the farmer holdings;
- Selection of the sites and study of the land resource conditions;
- Description of the soil and plant cover;
- Planting of the vegetation enhancing crops and other fodder crops;
- Observations of the fodder crops growth, development and survival rate;
- Development of the recommendations for pastureland management and fodder production.

2.9.3 Materials and methods

2.9.3.1 Research site

147. Field Research were conducted within the Abylay farmer holding (during 2008-2009 years) and Kuralas farmer holding (in 2009) of the Sarysu district, Jambyl province, Kazakstan (Figure 21).

148. Experimental sites were selected by mutual decision of the representatives of the Regional Office of ICARDA in Tashkent, Uzbekistan, Kazakhstan Research Institute of Soil Sciences and Agrochemistry named after U.U. Usmanov (Almaty city, Kazakhstan) and South-Western Research Institute of livestock production and plant industry as well as by the Administration of the Saryru district (Janatas city, Kazakhstan).

149. First experimental site (in Abylay farmer holding) is situated within the piedmont area of the Karatau mountains in the place called Jety-kyrka 7 km away from the Janatas city (Figure 22).

150. Second experimental site (also in Abylay farmer holding) is situated within the sandy areas of the Moinkum desert near the Bilaly artesian well which is 70 km from Janatas city.

151. Third experimental site (in Kuralas farmer holding) is situated within the rainfed zone of the Karatau mountain in the place called Ush-ata 17 km away from the city Janatas (Figure 23).

152. Climate of the region is continental. In accordance with the Baykadam meteorological station which is covering first two sites average annual air temperature is 9.80°C, while in accordance with the Lugovaya meteorological station that covers rainfed area of the Karatau mountain the average annual temperature 8.60°C [1].

153. The research area is distinguished with its dry climate. In accordance with the data collected during many years the average annual precipitation is 198 and 315 mm recorded by two meteorological stations, respectively, with 95 and 138 mm falling during cold seasons of the year (IX-III) and 103 and 177 mm during warm seasons of the year (IV-X).

154. Meteorological conditions during August 2007-September 2008 were draughty with the first precipitation falling by the end of November 2007. Stable snow layer covered the soil from the second half of December till the beginning of March. Spring was draughty with short precipitations during April-May. Summer was hot with subsequent precipitation starting at the beginning of October, 2008. Rainy period was observed during Autumn, 2008 – Spring, 2009. Draught in the year 2009 started from the second half the May. Analyzing the meteorological data the year 2008 was draughty while the first half of the year 2009 was humid.

155. Soil cover of the experimental site in Jety-Kyrka is represented by northern light gray soils. Humus content within the arable layer is 0.81-0.87%, hydrolyzed nitrogen - 39.2-50.1 mg kg⁻¹, mobile phosphorus - 8-36 mg kg⁻¹ and mobile potassium - 500-600 mg kg⁻¹. Gross content of phosphorus is 0.06-0.09% and of potassium is 2.1-2.2%. In terms of mechanical content soils are predominantly light loamy soils and in rare case represented by sandy-loam soils.

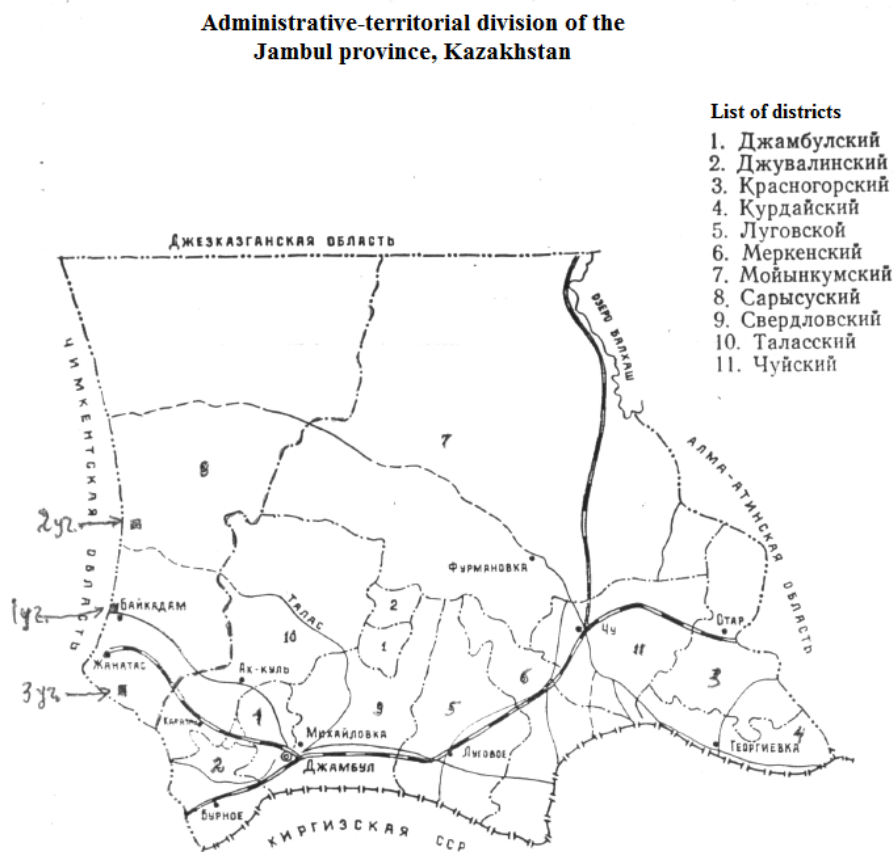


Figure 21. Scheme of the rangeland SLMR experimental sites in Kazakhstan

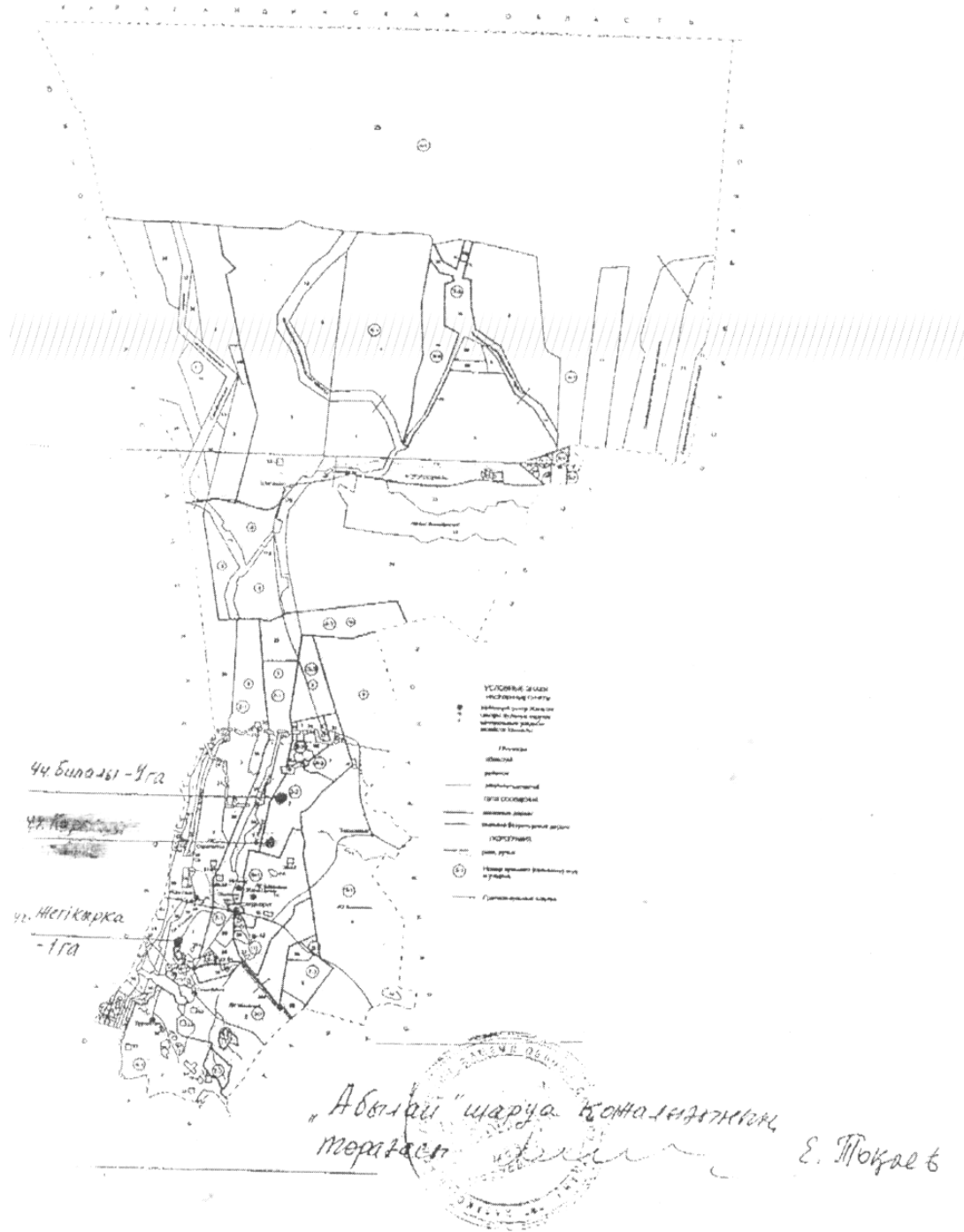


Figure 22. Territory of the Abylay farmer holding

№ 0043115

Жер учаскесінің ЖОСПАРЫ
ПЛАН земельного участка

Учаскениң орналасқан жері - Жамбыл облысы Сарысу ауданы Түркістан ӨК аумағындағы Ж.Тәжібаевтың ш/қ
Местоположение участка - к/х Тажибаева Ж на территории ПК Туркестан Сарысуского района Жамбылской области

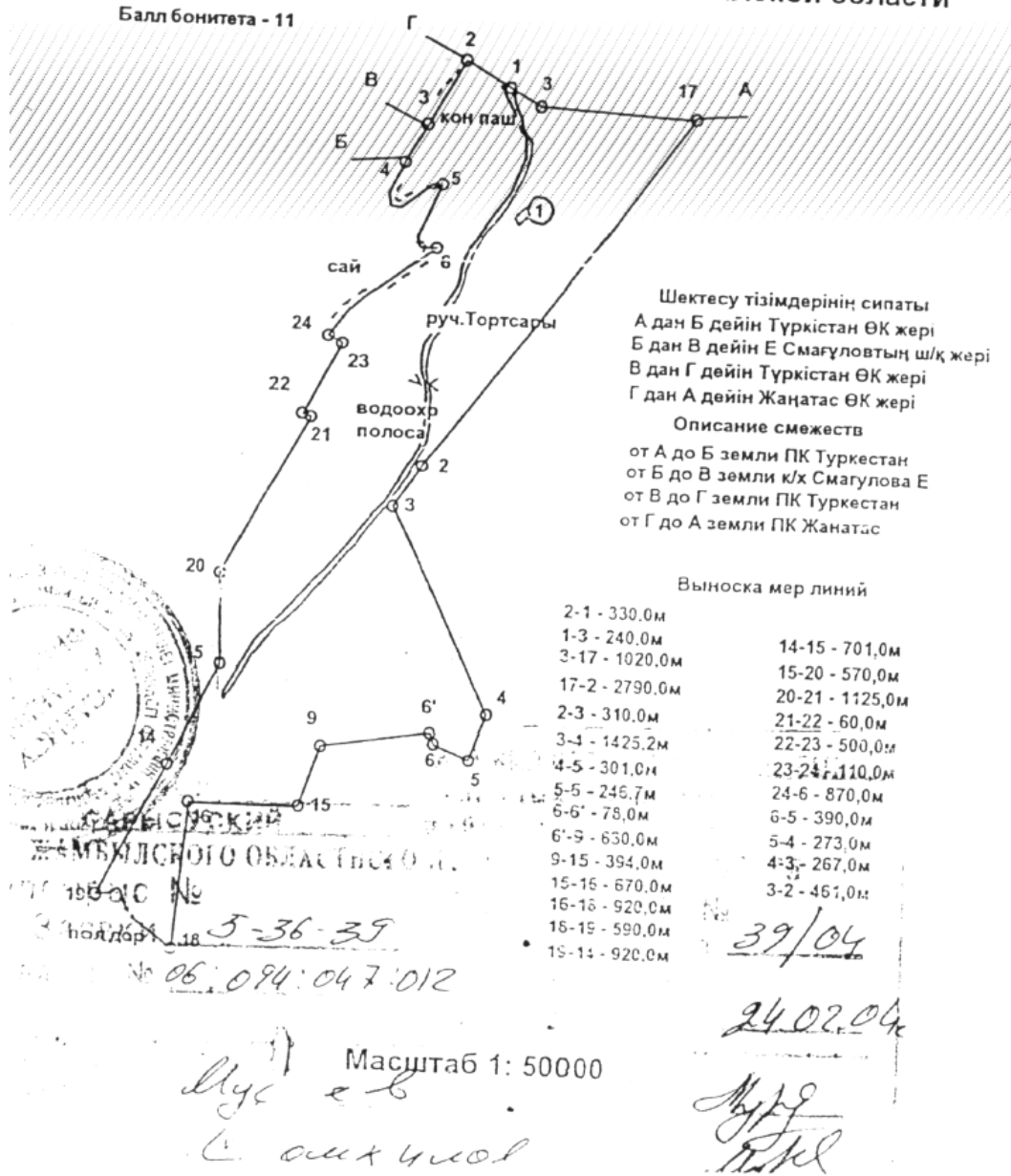


Figure 23. Territory of the Kuralas farmer holding

156. Soils of the second experimental site are represented by half-fixed sands with the humus content within the layer of 0-10 cm making up 0.31% which is decreasing at the layer of 10-50 cm making up 0.23%. The content of mobile nitrogen is average (36.4-42.0 mg kg⁻¹), while the content of phosphorus is low (31-48 mg kg⁻¹) and of potassium is satisfactory (190 mg kg⁻¹). Gross content of phosphorus fluctuates in the range of 0.02-0.03% and that of potassium is 2.19-2.31%. In terms of mechanical content sand is cohesive.

157. Soil cover of the third experimental site is more fertile which is represented by ordinary gray soils with the humus content p to 2%.

158. Vegetation covering 25-40% of soil on the first experimental site in Jety-Kyrka is represented by associations of *Artemisia* and ephemeral plants with predominance of *Artemisia*. The productivity of the pastures were fluctuating from 0.8 (2008) to 1.3 centner ha⁻¹ (2009).

159. Vegetation of the second experimental site in Bilaly is represented by grasses and shrubs with the associations of *Artemisia* and ephemeral plants. Hilly sandy areas are covered by *Calligonum* (Juzgun), *Eurotia* (Teresken), *Kochia* (Izen), *Agropyron* (Zhitnyak), *Stipa* – mat grass (Kovyl), *Poa* – snow grass (Myatlik) and others. Surfaces that are more or less flat are comparatively well fixed by grasses and shrubs.

160. Vegetation of the third site “Ush-ata” is represented by gramineous grass associations including *Onobrychis Chorasana* (Espartset Khorasanskiy) that was seed tested.

161. Areas in Jety-Kyrka and Bilaly are used as pastures while areas in Ush-Ata are used for growing cereals and oil producing crops as well as a hayfields.

162. Therefore, experimental areas are characterized by spacious changes in ecological, soil and climatic factors which is reflected in the growing vegetation.

2.9.3.2 Methodology

163. In order to fulfill research objectives Research were conducted in two following directions.

1. Selection of the phyto-ameliorative plants to improve the productivity of the natural pasturelands.

164. In this direction following plants were studied: *Sameriaria* (Vaida), *Onobrychis* (Espartset), *Agropyron* (Zhitnyak), *Kochia* (Izen), *Comphorosma*, *Eurotia* (Teresken), *Halothamnus* (Chogon), *Calligonum* (Juzgun) and *Haloxylon* (Saksaul). Study included the research on laboratory and field seed germination, dynamics of the plant density and plant survival rate including young germinated plants, phonological observations and plant growth dynamics.

2. Testing of triticale under rainfed conditions.

165. In this direction seed laboratory and field germination, growth rates and grain yields were studied as well as phenological research were conducted.

166. Laboratory germination was determined under the condition of indoor temperature during 15 days via methods of germinating seeds in Petri dishes in 3-4 replications with 50-100 seeds in each of the replications.

167. Field germination was determined by comparing the number of germinated seeds with the number of viable seeds. Dynamics of the plant density was determined during spring, summer and autumn. Phenological observations were conducted in accordance with the I.N. Beydenman's methodology [2]. Dynamics of the plant growth was determined via measuring the height of 10 plants. Grain yield of triticale was determined by cutting triticale plants within the area of 1 m² in four replications. Complete characterization of the triticale and wheat was given during the stage of waxy ripeness of the grain.

168. All experiments were conducted in accordance with the existent methodologies [3, 4]. Plantations of the phyto-ameliorative plants within the piedmont areas were conducted on 5 m wide strips with the inter strip distance of 10 m while on sandy areas plants were seeded on the 1.4 m wide strips with the inter strip distance of 10 m.

169. Triticale and wheat seeds were planted on rainfed arable area with the 1.5 ha under triticale. For soil preparation and seed planting MTZ-80 tractor, PN-3-45 ploughs and SZT-2,8 planter were used.

170. The received quantitative data was analyzed using statistical methods [5].

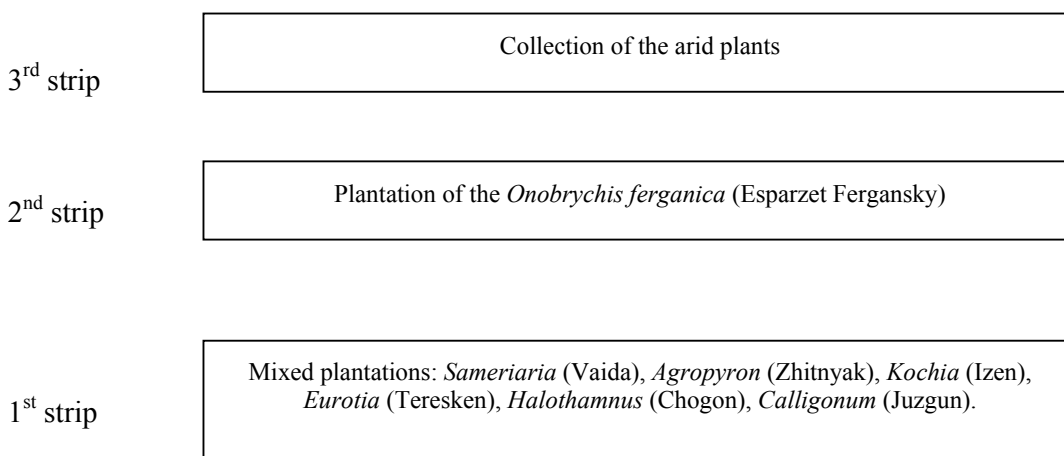


Figure 24. Scheme of planting phyto-ameliorative plants on the territory of the Abylay farmer holding, Sarysu district, Jambyl region, Kazakhstan: Site one: Jety-Kyrka (Yagodka)

Collection of the arid plants:

1. Vaida Buassie – *Sameriaria boissieriana*
2. Espartset Fergansky - *Onobrychis ferganica*
3. Espartset Khorasansky – *Onobrychis chorasanaica*
4. Zhitnyak Uzkokolosy – *Agropyron fragile*
5. Zhitnyak Grebnevidny from the Research Center Livestock production and camel breeding - *Agropyron cristatum*
6. Astragal Listovidny – *Astragalus alopecias*
7. Comphorosma Lessinga – *Camphorosma lessingii*
8. Lebeda from Sirya – *Atriplex nummubria*
9. Lebeda from Sirya – *Atriplex policarpa*
10. Solyanka from Siberia – *Salsola vermiculata*
11. Izen Seriy (Kamenistiy) – *Kochia prostrate var. canessens*
12. Izen Seriy K-118 – *Kochia prostrate var. villossima*
13. Izen Seriy II-2 – *Kochia prostrate var. villossima*
14. Izen Seriy II-28 – *Kochia prostrate var. villossima*
15. Izen Seriy K-5 – *Kochia prostrate var. villossima*
16. Izen Seriy – *Kochia prostrate var. villossima*
17. Izen Seriy K-121 – *Kochia prostrate var. villossima*
18. Izen Seriy K-822 – *Kochia prostrate var. villossima*
19. Izen Seriy II-30 – *Kochia prostrate var. villossima*
20. Izen Seriy K-131 – *Kochia prostrate var. villossima*
21. Izen Seriy K-735 – *Kochia prostrate var. villossima*
22. Izen Seriy K-831 – *Kochia prostrate var. villossima*
23. Izen Seriy K-820 – *Kochia prostrate var. villossima*
24. Teresken Seriy – *Krascheninnikovia ceratoides*
25. Teresken Eversmena – *Krascheninnikovia eversmanniana*
26. Cherkez Rikhtera – *Salsola richteri*
27. Chogon – *Halothammus subapliyillus*
28. Zhuzgun Kyzylkumsky – *Calligonum kzyl-kumi*
29. Saksaul from Sirya – *Haloxylon aphyllum*

Kazakhstan research report

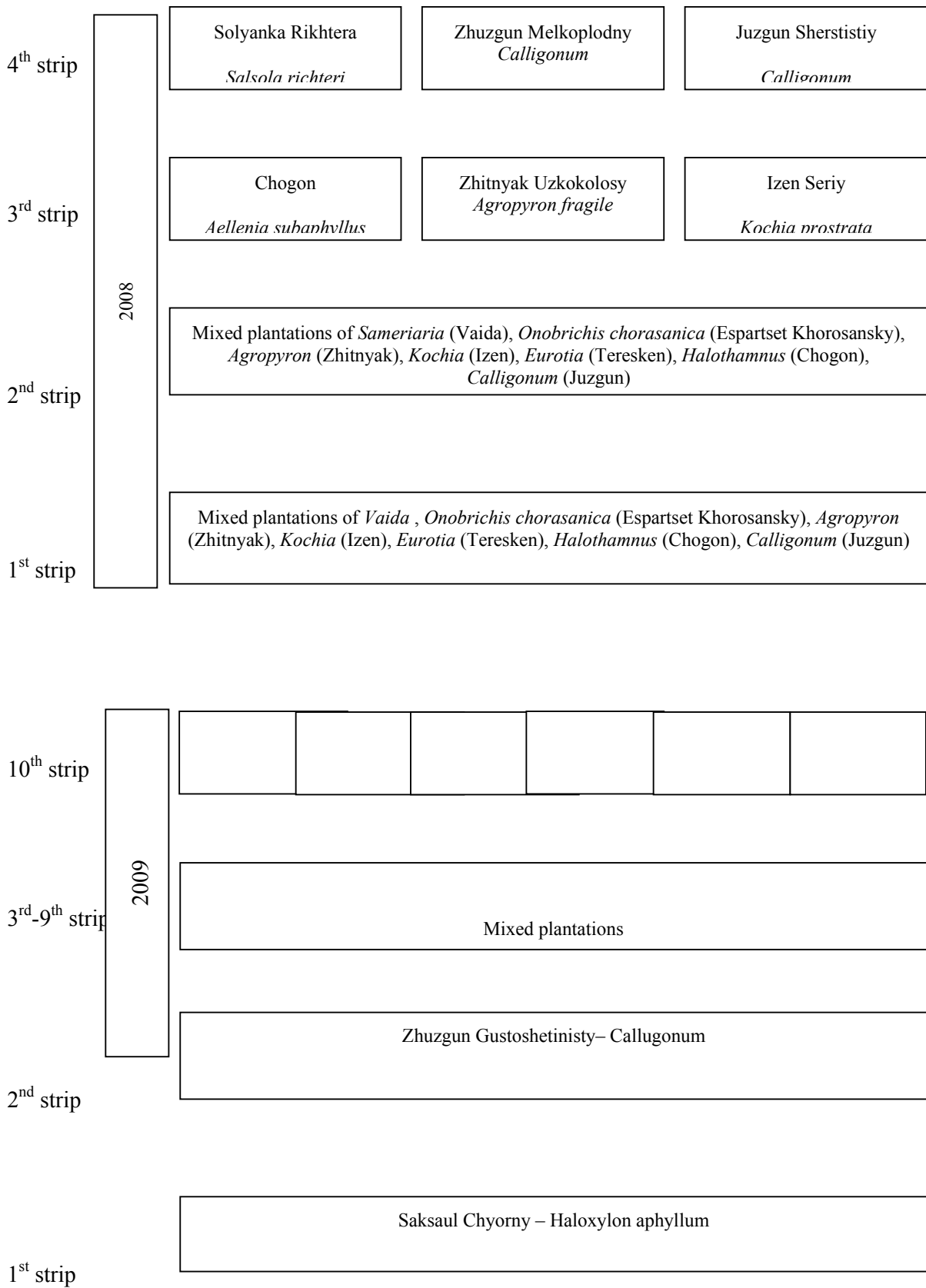


Figure 25. Scheme of planting phyto-ameliorative plants on the territory of the Abylay farmer holding, Sarysu district, Jambyl region, Kazakhstan: Site two: Bilala artesian well

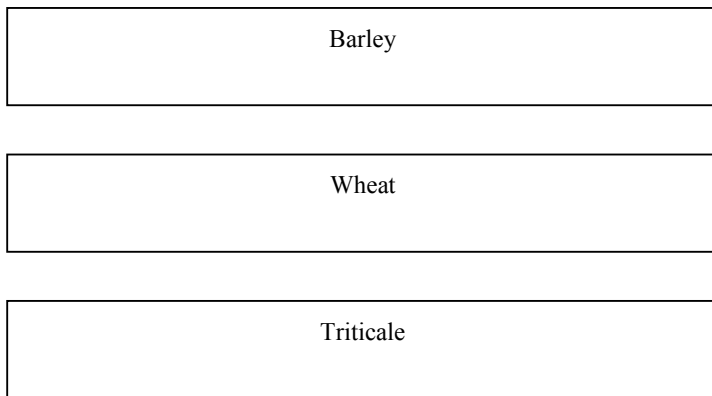


Figure 26. Scheme of planting phyto-ameliorative plants on the territory of the Abylay farmer holding, Sarysu district, Jambyl region, Kazakhstan: Site three: Ush-Ata

2.9.4 Results and discussions

171. Agricultural production complex of the Sarysu district of the Jambyl region is oriented towards livestock production especially Karakul sheep and camel breeding which is supported by the vast areas of pasturelands (1.61 million ha). Hayfields occupy only 5600 ha, arable rainfed lands - 4400 ha and irrigated lands – 4512 ha. Arable rainfed lands are used for growing winter wheat, while irrigated lands are occupied by alfalfa (2100 ha), maize (700 ha), fruit trees, vegetables and cucurbit crops.

172. Despite of the fact that the region is abundant with natural pasturelands that represent the source of fodder greater portion of these pasturelands is situated within the desert area. Hayfields are also distributed unevenly across the region.

173. The viable fodder supply for livestock is not determined solely by the area of the pasturelands and hayfields as the productivity of the natural pasturelands is fluctuating during the years and seasons.

174. Pasturelands should be used rationally as the density of the plant canopy and degree of the grazing is different during the seasons of the year. Therefore seasonal grazing has to be determined in accordance with the highest productivity and fodder value of the pastureland vegetation. Also it is important to use adequate pastureland rotation systems as well as enclosure-pasturing systems. Rational pastureland management in Betpakdala pasturelands during previous years when summer grazing was practiced resulted in the increase of the sheep population of the region up to 250 thousand heads. In autumn sheep were driven to the Moinkum deserts for wintering and during spring time sheep were kept in piedmont area.

175. After privatization of the sovkhoses the use of remote pasturelands became impossible due to financial and technical problems. This in turn leads to the overgrazing of the pasturelands near the settlements, water points leading to degradation of the pasturelands and loss of the valuable fodder plants. In accordance with the information of A.Tirekhanov, I.Alimaev and S.Orazbayev [6] 1.27 Ml ha are overgrazed in Jambul province.

176. Besides ecological problems there are social problems that should be resolved in order to maintain livelihoods in rural area where wellbeing of the families and rural communities depend on livestock. This necessitates the creation of the planted pasturelands and regulated pastureland grazing.

177. Issues of regulated pastureland grazing were studied by scientists of Kazakhstan Research Institute of livestock management and fodder production in the Moinkum desert [7].

178. However, there are still unresolved problems related to the pastureland improvement. Though at the beginning of 1990s specialists of the association “Kazpastbisha” conducted works on creation of the planted pasturelands on the area of 2000 ha within the Togusken complex unfortunately with the privatization of the sovkhoses this work was not continued leading to the complete destruction of the created planted pasturelands.

179. Many farmers in the area experience the lack of the concentrated fodder. In accordance with the recommendations of the scientists from the South Western Research Institute of livestock management and plant production 30 kg of concentrated fodder is required for one ewe and 20 kg for young female sheep [8].

180. The region has scarcity in the areas under cereal crops that are the sources of concentrated fodder. Winter crops grown on the rainfed areas provide the cheapest grain. However, this winter crops do not use the full potential of the climatic and soil resources of the rainfed areas. Up to present time alternative crops that can produce higher grain yields under the same soil and climatic conditions were not tested. Therefore, within the current research phyto-ameliorative crops were selected for the creation of the planted pasturelands within the desert area as well as triticale was tested for the purpose of receiving grain under the rainfed conditions.

2.9.4.1 Growth and development of the phyto-ameliorative plants

181. For substantial improvement of the pasturelands it is important to have a right collection of the perennial crops to be used for creation of the planted pasturelands as mistakes in this regards will affect the productivity of the pastures during the whole period of using them ranging from 8 to 15 and more years [9].

182. Selection of the phyto-ameliorative plans was conducted in 1993 on the experimental sites of the Abylay farmer holding that has an area of 3880 ha with the 5.4 ha of irrigated lands and 3800 ha of pasturelands.

183. Testing of the arid crops was conducted on two experimental sites: Jety-Kyrka (Yagodka) within the piedmont area of the Karatau mountains and Bilala well in Moinkum deserts (Figure 27).



Figure 27. Investigating land area of the Abylay farmer holding for conducting experiments

184. As a result of the expedition to Moinkum desert seeds of the following plants were collected Juzgun (*Calligonum eriopodum*), Teresken (*Krascheninnikovia ceratoides*), Izen (*Kochia prostrata* (L.) *Schrad.* var. *villossima*), Zhitnyak (*Agropyron fragil*).

185. Seeds of Esparzet (*Onobrychis chorasana*) and Teresken (*Krascheninnikovia ceratoides*) were collected in Karatau mountains.

186. In Kyzylkum area seeds of Astragal (*Astragalus alopecias*), Comphorosma (*Camphorosma lessingii*), Chogon (*Halothamnus subaplyllus*), Cherkez (*Salsola richteri*), three varieties of Juzgun (*Calligonum aphyllum*, *Calligonum kzyl-kumi* and *Calligonum microcarpum*) were collected.

187. Besides this, ICARDA has provided seeds of *Atriplex*, *Salsola vermiculata* and *Haloxylon aphyllum*, while seeds of Vaida (*Sameriaria boissieriana*), Esparzet (*Onobrychis ferganica*) and 12 samples of Izen (*Kochia prostrata*), Juzgun (*Calligonum densus*) were obtained from the collection of the South Western Research and Production Center of Agriculture.

188. All seeds were tested for their planting qualities in the laboratory of the South-West Research Institute of livestock management and plant industry (see Figure 28).



Figure 28. Seeds of arid crops. From top to bottom:

First row: *Sameriaria boissieriana*; *Agropyron fragile*; *Onobrychis ferganica*; *Onobrychis chorasanaica*; *Astragalus alopecias*

Second row: *Camphorosma lessingi*; *Kochia prostrate* var.villossima; *Kochia prostrate* var.canessens; *Salsola orientalis*; *Krascheninnikovia ceratoides*.

Third row: *Halothamnus sulaphyllus*; *Salsola richteri*; *Haloxylon aphyllum*; *Calligonum aphyllum*; *Calligonum eriopodum*.

189. Table 22 shows that the weight of 1000 seeds of long vegetating species like Izen, Teresken, Chogon, Saxaul was lower in the year 2008 in comparison with the year 2007. Indicators of the germination rate under the laboratory conditions were also lower for the year 2008. Meanwhile germination qualities of the spring and summer vegetating species such as Vaida Buasie, Zhitnyak and Espartset were the same for two years.

190. Better seed qualities of the yield of fodder crops for the year 2007 allowed achieving higher germination rates in the year 2008. For example, *Sameriaroa boissieriana*, *Agropyron fragile*, *Agroppiron cristatum*, *Atpiplex nummubria* and some samples of *Kochia prostrata*, *Krascheninnikovia ceratoides* planted within the nursery had a germination rate ranging from 43 to 150 plants m⁻² (Table 23).

Table 22. Weight of 1000 seeds and seed germination of the fodder crops of arid zone under the laboratory conditions

Specie	Weight of the 1000 seeds, gr		Germination under laboratory conditions, %	
	2007	2008	2007	2008
<i>Sameriaria boissieriana</i>	22.2	20.3	96	98
<i>Agropyron fragile</i>	1.9	1.9	83	91
<i>Agropyron cristatum</i>	2.3	2.1	68	79
<i>Onobrychis ferganica</i>	14.9	17.3	93	98
<i>Onobrychis chorazanica</i>	11.2	10.4	87	81
<i>Astragalus alopecias</i>	10.2	8.7	94	97
<i>Atriplex nummubria</i>	8.7	-	82	-
<i>Atriplex polycarpa</i>	2.3	-	98	-
<i>Salsola vermiculata</i>	4.5	-	14	-
<i>Camphorosma lessingii</i>	0.9	1.0	47	53
<i>Kohia prostrata</i>	2.1	2.0	66	54
<i>Krascheninnikovia ceratoides</i>	3.7	3.1	73	47
<i>Krascheninnikovia eversmanniana</i>	3.9	5.6	87	81
<i>Salsola richteri</i>	9.7	10.4	59	47
<i>Halothamnus subapyllus</i>	12.8	11.1	81	67
<i>Calligonum aphyllum</i>	21.8	29.9	27	41
<i>Calligonum microcarpum</i>	27.7	56.9	43	73
<i>Calligonum eriopodum</i>	40.0	27.4	61	41
<i>Haloxylon aphyllum</i>	5.4	4.3	23	44
<i>Calligonum densum</i>	41.0	44.8	57	59

Table 23. Seed germination rates and plant survival observed within the nursery planted with seeds from collections and within pasturelands planted with mixed plants (Jety-Kyrka site, 2008)

Type of plantation	Specie, samples	First year				Second year	
		25.IV	8.V	22.V	29.IX	4.IV	5.VII
1	2	3	4	5	6	7	8
Seeds from collections	<i>Sameriaria boissieriana</i>	71	-	-	-	17	13
	<i>Onobrychis ferganica</i>	29	2	-	-	2	2
	<i>Onobrychis chorazanica</i>	13	7	3	-	3	3
	<i>Agropyron fragile</i>	133	56	-	-	7	5
	<i>Agropyron cristatum</i>	150	31	-	-	8	7
	<i>Astragalus alopecias</i>	3	1	-	-	-	-
	<i>Atriplex nummubria</i>	43	21	-	-	-	-
	<i>Atriplex polycarpa</i>	21	7	-	-	-	-
	<i>Kohia prostrata</i> subsp. <i>grisea</i> BT-1	48	33	23	7	7	5
	K-118	31	13	11	-	-	-
	П-2	57	18	10	1	-	-
	П-28	13	10	7	1	-	-
	K-5	36	11	9	-	-	-
	BT-6	29	17	13	3	3	3
	K-121	67	28	11	3	3	3
	K-822	43	14	8	-	-	-
	П-30	21	7	3	1	1	1
	K-131	23	11	7	1	1	1
K-735	41	28	13	1	1	1	
K-831	36	21	17	-	-	-	
K-820	61	31	19	3	3	3	
1	2	3	4	5	6	7	8
Seeds from collections	<i>Krascheninnikovia ceratoides</i>	43	18	11	4	4	4
	<i>Krascheninnikovia eversmanniana</i>	34	24	13	2	2	2
	<i>Salsola richteri</i>	7	3	-	-	-	-
	<i>Halothamnus subapyllus</i>	21	13	7	2	2	2
Unmixed plantations	<i>Onobrychis ferganica</i>	37	18			7	5
Mixed plantations	<i>Sameriaria boissieriana</i>	28	-	-	-	3	3
	<i>Onobrychis ferganica</i>	21	13	-	-	5	3
	<i>Agropyron cristatum</i>	53	21	-	-	7	3
	<i>Kohia prostrata</i>	27	18	7	5	5	5
	<i>Krascheninnikovia ceratoides</i>	18	11	5	3	3	3
	<i>Halothamnus subapyllus</i>	13	5	3	3	3	3
	<i>Calligonum aphyllum</i>	7	-	-	-	-	-

191. Subsequent observations showed that due to the early draughts the germinated plants of *Sameriaria* (Vaida), *Onobrychis Ferganica* (Espartset), *Agropyron* (Zhitnyak), *Atriplex* (Lebeda) and Cherkez were rarified or in some cases even died. Better draught tolerance was observed for the samples of Izen (*Kochia*): BT-1, BT -6, K-121, K-820, Teresken (*Krascheninnikovia ceratoides*) and Chogon (*Aellenia subaphyllus*) that had plant density fluctuating between 2 to 7 plants m⁻². The same tendency was observed within the unmixed plantations of Esparzet (*Onobrychis Ferganica*) and mixed plantations of other species. All other plants had satisfactorily over-wintered. As climatic conditions of the year 2009 were more favorable plants of the second year were better preserved as it was observed at the beginning of July.

192. Within mixed and unmixed plantations on the site Bilal better survival rates were observed for Zhitnyak (*Agropyron fragile*). Survival rates for other crops is lower in comparison with the site Jety-Kyrka (Table 24)

Table 24. Plant density of the germinated seeds and plant survival within mixed and unmixed planted pasturelands (experimental site “Bilal”, 2008)

Plantation	Specie, sample	First year				Second year	
		25.IV	9.V	24.V	30.IX	5.IV	7.VII
1	2	3	4	5	6	7	8
Unmixed plantations	<i>Kohia prostrata subsp.grisea</i>	27	17	11	3	3	3
	<i>Agropyron fragile</i>	117	73	59	-	23	21
	<i>Halothamnus subapiyllus</i>	18	11	7	2	2	2
	<i>Salsola richteri</i>	7	3	1	-	-	-
	<i>Calligonum microcarpum</i>	4	2	2	-	-	-
	<i>Calligonum eriopodum</i>	7	5	2	1	1	1
Mixed plantations	<i>Sameriaria boissieriana</i>	11	-	-	-	-	3
	<i>Onobrychis chorazanica</i>	5	2	-	-	3	-
	<i>Agropyron fragile</i>	31	18	-	-	18	13
	<i>Kohia prostrata</i>	23	10	3	2	2	2
	<i>Krascheninnikovia eversmanniana</i>	13	7	3	2	2	2
	<i>Halothamnus subapiyllus</i>	17	8	5	2	2	2
	<i>Calligonum aphyllum</i>	13	7	2	-	-	-

193. Seeding qualities of many species in 2008 were comparatively low that affected the germination rate. Only *Haloxylon* had a satisfactory germination rate on both sites Jety-Kyrka and Bilal 3.5 and 10.1 plants m⁻², respectively. Amongst Izen (*Kochia*) varieties germination was observed only for the variety BT-1 (2.0 plants m⁻²). Plant density of Teresken (*Krascheninnikovia ceratoides*), Comphorosma (*Camphorosma lessingii*), Chogon (*Aellenia subaphyllus*) and Polyn (*Artemisia*) ranged from 1 to 4 plants m⁻². Following plant density was

observed on the site Bilal for Izen (*Kochia*) within unmixed plantations 3.2 plants m⁻² and 1.7 plants m⁻² within mixed plantation, for Teresken (*Krascheninnikovia ceratoides*) correspondingly 4.2 and 2.2 plants m⁻², Chogon (*Aellenia subaphyllus*) correspondingly 1.2 and 0.8 plants m⁻², Juzgun (*Calligonum*) correspondingly 1.8 and 1.2 plants m⁻² and Saksaul (*Haloxylon*) correspondingly 10.1 and 6.7 plants m⁻² (Table 25).

Table 25. Plant density and height within mixed and unmixed plantations (Site “Bilal”, 2009)

Type of plantation	Specie	Plant density, plants m ⁻²		Plant height, cm
		6.IV	8.VII	8.VII
Unmixed	Izen (<i>Kochia</i>)	3.2	2.9	23,6±2,0
	Teresken (<i>Krascheninnikovia ceratoides</i>)	4.2	3.0	23,1±1,8
	Chogon (<i>Halothamnus subaplyllus</i>)	1.2	0.9	27.0±1.8
	Juzgun (<i>Calligonum</i>)	1.8	1.5	43.0±3.9
	Saksaul (<i>Haloxylon</i>)	10.1	8.3	23.5±2.1
	Cherkez (<i>Salsola</i>)	0.9	0.5	10.7±0.7
Mixed	Zhitnyak (<i>Agropyron</i>)	9.1	8.3	31.0±2.7
	Izen (<i>Kochia</i>)	1.7	1.5	19.5±1.8
	Teresken (<i>Krascheninnikovia ceratoides</i>)	2.2	1.7	22.8±1.6
	Chogon (<i>Halothamnus subaplyllus</i>)	0.8	0.5	25.3±2.3
	Juzgun (<i>Calligonum</i>)	1.2	0.8	39.2±2.8
	Saksaul (<i>Haloxylon</i>)	6.7	5.0	19.7±2.5

194. Favorable conditions of the year 2009 resulted in a better survival rate of the young plants and their active growth and development. Table 25. shows that fewer plants died, linear growth of the plants is significantly high for the desert conditions. Plant height for Izen (*Kochia*) within unmixed plantations at the beginning of July was 23.6 cm and within mixed plantations 19.5 cm, for Teresken (*Krascheninnikovia ceratoides*) respectively 23.1 and 22.8, for Chogon (*Halothamnus subaplyllus*)– 27.0 and 25.3, for Juzgun (*Calligonum*)– 43.0 and 39.2, Saksaul (*Haloxylon*) – 23.4 and 19.7 cm. Plants of all species had well developed side offshoots and symmetrical leafage (рис.2.6, 2.7, 2.8, 2.9, 2.10).

195. Plant height of Cherkez (*Salsola*) was 10.7 cm and that of Zhitnyak within mixed plantations was up to 31.0 cm. Izen (*Kochia*) was at the stage of flowering. Lack of precipitation in April, 2008 effected plated pasturelands where plant height of many species was hardly 8-21 cm on both sites Jety-Kyrka and Bilal. Samples of Juzgun (*Calligonum*) grown on the site “Bilal” demonstrated comparatively better growth with the height of 11-25 cm.

196. Observations over the plants of the second year showed that at the beginning of April the height of Vaida Buasie (*Sameriaria boissieriana*) was 30 cm (Figure 2.11). Other species demonstrated comparatively low growth rates: Izen (*Kochia*) with the plant height of 7-8 cm, Teresken (*Krascheninnikovia ceratoides*) 4-5 cm, Espartset (*Onobrychis*) - 8-10 cm, Polyn (*Artemisia*) - 2-3 cm, Chogon (*Halothamnus*) – 0.5-1 cm, Juzgun (*Calligonum*) - 3-5 cm.

197. At the beginning of July the height of Izen (*Kochia*) was 21.3, Teresken (*Krascheninnikovia ceratoides*) – 27.0 and Chogon (*Halothamnus*) - 34.5 cm. On Bilal site the height of Vaida within mixed plantations was 73.0 cm, Zhitnyak (*Agropyron*) - 43, Izen (*Kochia*) - 37, Teresken (*Krascheninnikovia ceratoides*) - 41, Chogon (*Halothamnus*)- 56 cm. Height of Juzgun (*Calligonum*) within unmixed plantations was 51 cm. Vaida (*Sameriaria*) and Zhitnyak (*Agropyron*) were at a fruiting stage (Figure 2.12). Izen (*Kochia*) was at the beginning of the flowering stage and Chogon (*Halothamnus*) at the bud formation stage. While bushes of Juzgun (*Calligonum*) were green yet.

198. The results of the two year experiment showed that within the piedmont area more resistant were Vaida Buasie (*Sameriaria boissieriana*), Izen (*Kochia*), Teresken (*Krascheninnikovia*) and Chogon (*Halothamnus*) while within the sandy areas resistance to unfavorable factors was demonstrated by Vaida Buasie (*Sameriaria boissieriana*), Zhitnyak (*Agropyron*), Teresken (*Krascheninnikovia*), Chogon (*Halothamnus*), Juzgun (*Calligonum*) and Saksaul (*Haloxylon*).

2.9.4.2 Testing of triticale within the rainfed area

199. At present a great number of different forms of amfidiploids were created in many countries including Kazakhstan by scientists in order to combine best qualities of two plants, namely: high winter resistance of rye and its ability to grow on different soils and under different climatic conditions, on the one side, and high yields of winter wheat, on the other side.

200. Winter varieties of triticale were created in the Krasnovodapad breeding station. These varieties have high yields, great winter and pest resistance therefore seeds of these varieties do not need pre-sowing treatment. Triticale contains more protein in comparison with wheat and rye. Thus, protein content within the wheat grain is 10.4% while within the triticale grain is 12.6% [10].

201. In November 2008 in accordance with the proposal of Dr. R.Gupta (ICARDA) Orda variety of triticale was planted on the fields of Kuralas farmer holding. Steklovidnaya variety of wheat and Orda variety of triticale germinated at the beginning of March. Height of wheat plants at the beginning of April was on average 8.5 ± 0.7 cm and that of triticale was 11.7 ± 1.06 cm (Table 26). Triticale plants had well developed roots (Figure 29). On average wheat plants had 3.6 ± 0.4 roots and triticale plants – 5.6 ± 0.6 . Naturally, well developed roots stimulate more efficient use of moisture and nutrients resulting in better development of the plant.



A-triticale

B- wheat

Figure 29. Germinated plants of triticale and wheat

202. As it can be seen from the Table 26 during the stage of waxy ripeness the height of triticale was 79.6 ± 0.9 cm which 17 cm higher in comparison with the wheat plants. It is known that plant height has significance for breeding intensive varieties. Some researchers consider triticale plants that have on average the height of 80-100 cm as a more interesting samples as they have greater fertility and better quality of the grains [10]. On our experiments plants had the height ranging from 67 to 91 cm (Figure 30).



Figure 30. Triticale plants at the stage of waxy ripeness

203. Plants of triticale formed on average 2.1 tillers while wheat 1.5.

204. Comparison of two crops in terms of length of the head and number of grains showed that triticale has more advantages. The length of heads in wheat plants on average was 8.0 ± 0.4 cm and that of triticale - 9.5 ± 0.3 cm (Figure 31). In terms of grain number triticale plants were also ahead with 51.0 ± 3.2 grains.



Figure 31. Determining the yields of triticale and wheat

205. Biological yield (total biomass) of triticale was 5.6 t ha^{-1} while yield of wheat was 4.83 t ha^{-1} . Weight of 1000 grains was respectively 29.2 and 27.0 g.

206. The results of this experiment, thus, shows the effectiveness of growing triticale under the rainfed conditions of Sarusu district, Kazakhstan.

207. As a result of conducted research work project implementation team has prepared album of the arid crops, organized workshop on triticale with publication of the workshop materials on local newspapers.

208. Project implementation team is thankful to Dr. R. Gupta, Dr. K. Kienzler, Assistant D. Tursunova and National Coordinator, Prof. A. Saparov for continuous support and valuable advice during project realization and organizing the workshop (Figure 32).

Table 26. Characteristics of the Steklovidnaya variety of wheat and Orda variety of triticale (site Ush-Ata, November planting, 2008)

Variety	Germinated plants		Waxy ripeness				
	Number of roots	Root length, cm	Plant height, cm	Number of shoots	Number of joints within the stem	Length of the head, cm	Number of grains
<i>Steklovidnaya</i>	3.6 ± 0.4	8.5 ± 0.7	62.6 ± 1.8	1.5 ± 0.2	5.0 ± 0.1	8.0 ± 0.4	36.9 ± 2.3
<i>Orda</i>	5.6 ± 0.6	11.7 ± 0.6	79.6 ± 0.9	2.1 ± 0.3	5.5 ± 0.1	9.5 ± 0.3	51.0 ± 3.2

2.9.5 Conclusions

209. Stable development of the livestock production in Sarysu district of the Jambul province, Kazakhstan, depends on the condition of pasturelands. Current conditions restrict the development of livestock production within the desert areas and one of the ways to resolve this problem is to create planted pasturelands using the fodder plants suitable for arid zones as well as using alternative crops for fodder production on the arable fields

210. Experimental studies of the collections, mixed and unmixed plantations of fodder crops in arid zones showed that within the piedmont areas most perspective species for creation of the planted pastures are Vaida Buasie (*Sameriaria boissieriana*), Izen (*Kochia*), Teresken (*Krascheninnikovia*) and Chogon (*Halothamnus*) while for desert areas of Moinkums – (*Sameriaria boissieriana*), Zhitnyak (*Agropyron*), Teresken (*Krascheninnikovia*), Chogon (*Halothamnus*), Juzgun (*Calligonum*) and Saksaul (*Haloxylon*).

211. Alternative crops such as triticale play important role for resolving the problem of fodder deficit. Testing of the Orda variety of triticale showed that under the rainfed conditions biological yield (biomass for fodder) of triticale was 5.6 t ha⁻¹ and yield of Steklovidnaya variety of wheat was 4.83 t ha⁻¹.

212. We think that Research on these issues should be continued as they have social, economic and ecological importance for the local population.

2.10 Kazakhstan: Activity 8. Dissemination of results and development mechanisms for implementation and widespread dissemination of SLMR methods

2.10.1 Purpose of the Seminar - Acquaintance of farmers, publicity with main results of the project on I-UUZR.

213. To disseminate knowledge on sustainable management of irrigated land resources and more profound understanding of conducted experiments on the basis of Company Ltd. «Kaptagay and K» the National team of executors of the project by the UUZR in 2008 has conducted a field seminar inviting farmers from two neighboring districts (Figure 32): Shieli and Zhanakorgansky in Kyzylorda region which are located in pre-delta of Syrdarya river in the same soil and climatic conditions. The seminar was also attended by representatives of the local and regional level - First Deputy local governor (“Akim”) of Kyzylorda region on Agriculture, specialists of Regional Department of Agriculture, Deputy local governor (“Akim”) of Shieli district, specialists Department of Agriculture of Shieli district, staff of the big regional investment firm «Dihan» and others.

214. The program of the seminar included a demonstration of experiments on I-UUZR-raised-bed technology of rice cultivation and demonstration of Indian seeder used for raised-bed taken from the project ICARDA, field inspection of the new varieties of rice of Kazakhstan and Russian breeding and processing of rice seeds with growth stimulant Mars and sodium humate, presentation of results of soil-reclamation and soil-agrochemical evaluation of the fields of Company Ltd «Kaptagay» etc.

215. Also the work of the only in Kazakhstan optical sensor "Greenseeker" was demonstrated designed for remote monitoring of the growth and development of plants, and nitrogen regime management.

216. All people who were present at presentations mentioned about the high efficiency of the proposed technologies.

217. On 15-16 July 2009, a similar seminar is planned on the results of the project I-UUZR on the Abylai and Shieli plots.





Figure 32. Workshop on Sustainable land management in Kazakhstan.

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3 Kyrgyzstan research report

3.1 Kyrgyz research team

Table 27. Benchmark site 27 (Daniyar)

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Site Coordinator, Agronomist, Kyrgyz Farming Research Institute	L. Martynova
Soil Scientist, Agronomist, MAWMPIK	G. Elemanova
Hydraulic Engineer – Irrigator, Head of the Laboratory, Kyrgyz Research Institute for Irrigation	P. Jooshev
Plant Protection Specialist, Plant Chemicalization, Quarantine and Protection Department, MAWMPIK	N. Mokshina
Senior Researcher, Biologist, Biotechnology Institute	B. Asanakunov
Farmer-Agronomist of the Daniyar farm	O. Mamaev

Table 28. Benchmark site 28 (Kenenbay)

Site Coordinator, Irrigation Specialist, Kyrgyz Research Institute for Irrigation (KRII)	A. Atakhanov
Principal Scientist, Irrigation Specialist, KRII	A. Naloychenko
Senior Scientist, Agronomist, KRII	S. Pismenniy
Senior Scientist, Hydraulic Engineer, KRII	R. Madumarov
GIS Laboratory Specialist, KRII	N. Zemlyanskaya

3.2 Time schedule of research activities in Kyrgyzstan 2007-2009

Table 29. Time schedule of research activities in Kyrgyzstan 2007-2009

Kyrgyzstan	Qr3	Qr4	Qr1	Qr2	Qr3	Qr4	Qr1	Qr2	Indicators	Outcomes
1. Evaluation of performance of new cultivars (wheat, barley) suited for different tillage systems for improved water productivity in shallow groundwater table conditions	X	X	X	X	X	X	X	X	Reports Improved cultivars and seed availability	Institutions use the methodologies of comparative evaluation of SLM interventions
2. Study the effect of different herbicide molecules (pre- and post-emergence) on weed dynamics and water productivity for increased farm incomes	X	X	X	X	X	X	X	X	Technologies on use of multi-quality waters	Farmer start custom services and SMEs initiate agribusinesses
3. Study the effect of controlled irrigation methods for improving crop-water productivity, and reduce irrigation-induced soil erosion		X	X	X	X	X	X	X	Methodology for assessment of the agronomic and crop management interventions on growth and land quality	Farmers use improved seeds
4. Effect of conjunctive use of fresh and drainage water on crop yields and soil salinity build-up		X	X	X	X	X	X	X		
5. Evaluate the impact of laser-assisted land leveling on water savings, salinity and crop yields in irrigated agro-ecologies				X	X	X	X	X		
6. Calibration and use of the Greenseeker for measuring crop development, comparing crop management practices and efficient nitrogen management			X	X	X	X	X	X		
7. Dissemination of results and developing mechanisms for upscaling and outscaling of the SLMR options			X	X	X	X	X	X		

3.3 Overall introduction

218. Croplands of Kyrgyzstan constitute for about 1.4 million ha, that is 7% of the total area. Productivity of these lands for 70% depends on irrigation. The most serious problem is their degradation: every year thousands of croplands get out from agricultural turnover due to salinity, water logging lost of pit-run fines because of irrigational erosion, as the irrigation is carried out on big slopes of 0.05 – 0.07 and more. Ecological problems are getting worse because of big amount (more then 200 000) of rather goods peasant economy, an average rate of which is made 4-5 ha. This interrupts normal crop rotations, usage of advanced soil tillage methods, and introduction of progressive irrigation methods. Products producing are carried out by extensive method, and because of this fertility of croplands, quality of products is getting worse and this stipulates the reducing of life level in the village.

3.3.1 Research set-up and problem setting

219. Experiments for lands management are carried out in the farm “Daniyar” which is located in 30 km from Bishkek city.

220. Experiment site “Daniyar” was chosen for Research according to the following parameters:

- Located in the central part of Chuyskaya valley and characterized by common farms’ problems in this area;
- Soils of the site are heave loamy, that stipulates their multiple tillage which leads to the spoiling of agro physical features;
- Groundwater are found at the depth of 2.5-3.0 m, and during irrigation and snow melting period it increases up to the level of 0.5-0.7 m due to the bad condition of drainage network;
- Groundwater is partially saline and repeatedly soil salinization in root layer is observed;
- There is no crop rotation because of small area of farms, cropping practices are carried out according to the simple technology due to lack of necessary agricultural set of techniques;
- Fertilizers and plant protection facilities are used in the limited amount for the lack of money;
- Farmers use the seed grains of low quality;
- Farmers frequently burn plant residues because they do not have seeders for sowing in the stubbles.

3.3.2 Objective

221. The purpose of this research was determined coming out from the problems mentioned above: reclamation of 6 fields rotation crops, which is able to provide the improvement of agro-physical soil features to decrease land degradation, to provide growth of cropping productivity in the range of 25-30%.

3.4 Kyrgyzstan - Experiment 1. Investigation of crop rotation and irrigation methods for an effective water usage and reducing the soil degradation

3.4.1 Introduction

3.4.2 Objective

222. To determine the influence of crop rotation with diversification of grains legumes in farms' conditions.

223. Tasks of research:

- Selection of farm and carrying out the inspection for creating the experimental site;
- Launching of crop rotation on the farm lands in conditions maximum close to the average level of farm industry;
- Diversification of grains and legumes;
- Appliance of various system for soil tillage;
- Appliance of better irrigation methods;
- Investigation of water physical and argo physical soil features;
- Investigation of moisture dynamics and Groundwater' level;
- Investigation of the possibility to use drainage waters and their influence on a soil salinization and crops' productivity.
- Efficiency of using herbicides.

224. The assigned tasks are solved by carrying out a number of experiments.

3.4.3 Materials and methods

225. Agro physical, agro chemical features of soil are investigated in the experiment. Phonological observations and estimation of soil tillage method's influence on species and qualitative composition of weed vegetation are carried out. Soil moisture regime is determined on maize crops in order to define terms and norms of irrigation. Observations are carried out for Groundwater' levels and their mineralization. Agro biological and agro chemical Research are carried out in 5 points of each plot. Samples are taken by the envelop method. Reap samples were taken from the grain crops before harvesting for determination of yield structure, which are now analyzed. All the Research are carried out according to the generally accepted methodology recommended for this zone.

3.4.3.1 Soil climatic conditions

226. Zone's climate is sharp continental with cold winter and dry hot summer. Average annual air temperature is +9.60C. Length of frost-free season is 170 days. Late frosts are observed frequently in the zone in the first decade of May and early temperature decreases to the negative degree in the second decade of September. Precipitations take place up to 450 mm per year.

227. Thus, in 2008 the last frost of -90C was registered on 18 April, as a result of which part of winter grain crop died. In autumn 2008 stable temperature change in each - 50C was recorded at the end of October, in the first decade of November took place the first snow, which negatively impacted on the young growths of winter crops, which met winter without tillering.

228. Spring 2009 was late and with precipitations. In April precipitation was in two times more then annual average data (Table 30). Cool rainy weather shifted development phase of winter crops and sowing terms of spring crops.

Table 30. Weather data for vegetation period of 2008 – 2009

	months								
	XI	XII	I	II	III	IV	V	VI	VII
	2008 – 2009								
Average air temperature	4.6	-0.5	-1.0	1.6	7.7	11.0			
Precipitation, mm.	42.8	25.0	21.1	51.7	52.6	113.2			
	annual average data of 1965 – 2000								
Average air temperature	4.6	-3.2	-2.8	-3.2	4.7	12.8	17.6	22.5	24.9
Precipitation, mm.	53.1	19.5	21.2	30.7	50.8	66.5	61.9	35.2	24.9

Note: data of "Bishkek-pole" weather station. Portable ICARDA weather station shows wrong data from August 2008.

229. Soils of experiment site "Daniyar" are meadow grey desert, heavy loamy, repeatedly salted. For the moment of land investigation (1980) soil contained in plough-layer: humus – 2.5 – 3.5 %, gross nitrogen – 0.20 %, phosphorous – 0.2 – 0.23 %, potassium – 2.5 – 3.8 %. Reaction of soil environment was slight alkaline. Soils of low carbonate, but with depth of CO₂ content increase and achieves 10.5 – 16.7 %. Absorption capacity is 12 – 15 mg/eqv for 100 g of soil. In composition of absorbed basement prevails calcium and magnesium.

230. For the moment of experiments carried out in experiment site "Daniyar" physical chemical characteristics were as follows (Table 31).

Table 31. Physical chemical characteristics of the soils

Selection place	Depth, sm.	Humus, %	Gross content, %		
			N	P ₂ O ₅	K ₂ O
Farm "Daniyar"	0-30	1.09	0.13	0.22	3.27
	30-50	0.82	0.08	0.13	3.29
	30-50	0.92	0.11	0.23	3.51

231. Humus content in the farm is little - 1.09 - 0.82 %. Gross nitrogen is even less - 0.08 %. Gross phosphorous is made 0.22 - 0.13 %, estimated as middle supplied. Gross potassium is enough -3.19-3.27%. Soil environment reaction is pH-9.1.

232. According to the results of soil investigations conclusion can be done that in the experiment site "Daniyar" soil environment reaction is estimated as heavy alkaline. According to the content of dry residues, soils are not so salted and not alkaline. In order to neutralize the soil environment's reaction it is necessary to carry out appropriate reclamation activities, in particular application of gypsum.

233. Investigated soils according to the humus and nitrogen rates are characterized as low supplied. At present time this phenomena is inherent to all soils of Chuyskaya valley. As for phosphorous, its amount is estimated as average. Content of gross calcium is enough in the soils that is announced as potential reserves of this element in hard phase of soil.

234. Organic and nitrogen fertilizers should be applied in order to increase fertility of investigated soils.

3.4.3.2 Field activities

235. The following agro technical activities were carried out at the experiment site "Daniyar" in autumn (Table 32).

236. Irrigation of winter crops was not carried out due to plenty of spring precipitation. Perspective varieties of winter wheat "Intensivnaya" and "Asyl" (foundation seed) were used as a sowing material.

237. Depth of seeds placement at ordinary and raised-bed sowing has been made 5-6 cm at zero till - 2-3 cm. Monitoring for the quality and compliance of optimal parameters was held while carrying out the agro technical activities. Plough's adjustment to the given depth and seeders' installation (ordinary and raised-bed) was carried out for the sowing rate. Demonstration of raised-bed seeder and its operation was held to the neighbor farmers during winter crops sowing.

238. Winter crops' germination appeared only on 14 November. Wheat came to winter without tillering. The following agro technical activities were carried out at maize crops (field № 1, experiment 2.4).

Table 32. Agro technical activities carried out at winter crops. (After № 4 experiment 1)

№	Date	Course of work	Dosage, norms, depth
1	5-6/IX-08	Cutting of temporary sprinklers	
2	20-25/IX-08	Pre-plowing irrigation	1000m ³ ha-1
3	20/X-08	Leveling of irrigation network	
4	23/X-08	Fertilizers application (ammonium phosphate)	N ₁₄ P ₆₀
5	25-26/X08	plowing moldboard	25-28 sm
6	27/X-08	Pre-sowing tillage (<i>мала</i> +harrow)	6-8 sm
7	28/X-08	Winter crops sowing (experiment 1) - ordinary - zero - raised-bed sowing	220 kgha-1 110 kgha-1 110 kgha-1
8	20/II-09	First extra nutrient with harrowing (ammonium nitrate)	N ₃₀
9	20/II-09	Second extra nutrient (ammonium nitrate) with application herbicide "Istrebitel" (tank mixture)	N ₃₀ 20 gha-1
10	12/VII-09	Winter crops harvesting	Direct combine harvesting

Table 33. Agro technical activities at maize crops.

№	Date	Course of works	Dose, norms, depth
1	20-25/IX-08	Pre- plowing irrigation	1000 m ³ ha-1
2	25/X-08	Fertilizers application (ammonium phosphate)	N ₁₄ P ₆₀
3	30/XI-08	moldboard plow	25-28 cm.
4	20/II-09	Prevernal harrowing	4-6 cm.
5	23/III-09	Laser assisted land leveling	
6	15/IV-09	Solid cultivation with fertilizers application (ammoniac nitrate)	12-14 cm. N ₃₅
7	25/IV-09	Pre-sowing tillage	8-10 cm.
8	10/V-09	Maize sowing (raised-bed) with fertilizers (ammonium phosphate)	25 kgha-1 N ₁₃ P ₅₇
9	12/V-09	Application of pre-germination herbicides	Stomp 5lha-1 Esteron 0,6 lha-1
10	26/V-09	Cultivation of raised-beds at the farmer's site	10-12 cm.
	5/VI-09	Herbicides application on vegetated plants	Dialen 1lha-1 Titus 40 gha-1
11	10/VI-09	Manual weeding at farmer's site	
12	20/VI-09	Cutting of irrigation furrow with extra nutrient (ammoniac nitrate)	14-16 cm N ₃₆
13	24/VI-09	Preparation for irrigation, installation of water assessment facilities	
14	26-28/VI-09	First maize irrigation	650m ³ ha-1
15	10-11/VII-09	Second maize irrigation	700 m ³ ha-1

239. Maize sowing was done by hybrid seeds “Ala-Too”, standard is 25 kg ha⁻¹, by new raised-bed planter on 79 cm wide raised-beds. Germination came up on May 17. Density after germination has been made 85.7 thousand plant ha⁻¹.

240. Sowing of grain legumes crop - soybean was carried out on the field № 2. “Evrika” variety, sowing rate is 80 kg ha⁻¹. Sowing was done on 5 April by new raised-bed planter on 70 cm wide raised-beds. There are 2 lines in the raised-bed. In autumn 2008 laser planning of field was carried out at this site for experiment № 5. Formed sloop of 0.007 turned out to be dangerous for erosion, due to this repeated planning was carried out in spring for creating the sloop of 0.004. Fertilizers (ammonium phosphate) were applied in calculation of N14P60 before sowing. By the time of writing Report, manual weeding, cultivation with cutting irrigation furrow and 2 vegetation irrigations were carried out at soybean crops.

241. On the field № 3 spring barley “Bestam” is cultivating with sub-induviate alfalfa according to raised-bed technology. “Super-elita” seeds of KyrNIIZ breeding will be sold to neighbor farmers.

242. Sowing rate of barley is 140 kg ha⁻¹, alfalfa (“Bereke” variety) is 10 kg ha⁻¹. Before alfalfa’s germination, sowings were treated by herbicide “Istrebitel” in calculation for 20 g ha⁻¹. Sowings are clean; irrigation was not done due to the plenty of spring precipitation.

243. Thank to farmer’s initiative direct sowing of winter wheat into the raised-beds, which left after previous maize crop was carried out in the part of the field. “Asyl” (foundation seed) with sowing rate of 110 kg ha⁻¹ was done in three lines.

3.5 Kyrgyzstan: Activity 1. Evaluation of performance of new cultivars (wheat, barley) suited for different tillage systems

3.5.1 Introduction

3.5.2 Objective

244. Quality assessment of new varieties of winter wheat at various systems of soil tillage.

245. Tasks: To determine winter wheat varieties which are appropriate to the new methods of tillage.

3.5.3 Materials and Methods

3.5.3.1 Experiment scheme

246. 2 varieties of winter wheat at 3 tillage methods are studied in the experiment (field № 4).

1. Sowing into the non tillage stubble (zero).
2. Raised-bed sowing
3. Farmer's practice – solid sowing

247. Breeding varieties of Kyrgyz NII agriculture are used: A) “Asyl” variety; B) “Intensivnaya” variety.

Field № 4					
A	A	A	B	B	B
3	2	1	1	2	3

Figure 33. Plan of experiment placement on the field № 4

248. Width of raised-bed on the raised-bed sowing is 0.6 m, there are three lines on the raised-bed. At solid sowing the width between lines is 0.15 m.

249. Pre-ploughing irrigation was done at the site from 20 to 25 September, rate of which has been made 1000 cubic m ha⁻¹. Soil tillage according to the scheme was carried out on 25-26 October 2008 to the depth of 25-28 cm. In direct sowing (stubble sowing) soil tillage did not take place. Winter crops' sowing was carried out on 28 October 2008.

250. Sowing was done with some delay because of the rainy and cold autumn. It snowed in the first decade of November and temperature fall down to subzero. (Portable weather station shows wrong data from August). In spring winter crops were dressed by ammoniac nitrate in calculation of 30 kg ha⁻¹ of nitrogen to hectare. After winter condition of crops was satisfactory.

3.5.3.2 Phenological observations

251. While comparing the varieties between each other, it was noted that “Intensivnaya” has begun spring vegetation 2 days earlier than “Asyl” variety. “Intensivnaya” has begun booting phase 4-6 days earlier. To the moment of flowering gap between varieties has been made 4 days on solid crop and 4 days on raised-bed planting. At zero till beginning from the booting phase, growing took place 2 days earlier, heading was 3 days (Intensivnaya) and 4 days (Asyl) earlier in comparison with solid method of sowing. But in the middle of May the weather was hot and dry, as a result of which break at the beginning of milky ripeness has been reduced at zero till to 2 days in “Intensivnaya” variety and to 3 days in “Asyl” in comparison with solid sowing. The next phases of vegetation started 2 days earlier than at solid sowing. At zero till the next phases of growing started from tillering took place 2-4 days earlier than at solid sowing (Table 4).

252. It should be pointed out that “Asyl” variety which grows on the raised-beds according to zero technology (field №3) ripened 10 days earlier than the solid sowing, and 8 days earlier than on raised-bed sowing (field №4), where raised-beds were formed on plough-land.

3.5.4 Results and discussion

3.5.4.1 Density of plants

253. Observation for density of standing showed that at solid sowing density of winter crops was higher than at raised-bed sowing for the account of different sowing rate. Excess is made 56.8 % in “Intensivnaya” variety and 57.5 % in “Asyl” variety. The lowest density of planting was observed at zero till. Field germination of plants was higher in “Intensivnaya” variety in all tillage methods. Inside the varieties higher field germination was observed at raised-bed sowing. Tillage germination reduces at zero till because of unsatisfactory seeds placement into the not plowed soil (Table 32).

254. After wintering thicker sowings were observed also at solid method than at raised-bed and zero methods. Grains passed winter favorably and after the vegetation renewal plants’ reservation was high enough (Table 32). The following differences were observed according to the varieties: higher preservation of 90.7 % was on the solid sowing with winter wheat “Asyl”. Winter wheat “Intensivnaya” has higher preservation also at solid sowing – 89.1 %. At zero till preservation of both wheat varieties has been made 87.2 - 82.6 %.

Table 34. Winter crops density depending on the ways of tillage.

	Standing density, pcs/m ² according to the tillage						
	Winter wheat “Asyl” direct sowing	Winter wheat “Asyl”			Winter wheat “Intensivnaya”		
		Solid	Raised-bed	Zero	Solid	Raised-bed	Zero
Sown, pcs/m ²	250	450	250	250	450	250	250
After full germination	192	344	198	172	366	208	184
Field germination, %	76.8	76.4	79.2	68.8	81.3	83.2	73.6
After winter	168	312	175	150	326	184	152
% of preservation	87.5	90.7	88.4	87.2	89.1	88.1	82.6
Before harvesting	147	216	168	126	225	170	120
% of preservation	88.0	69.2	96.0	84.0	69.0	92.4	78.9

255. By the time of cleaning preservation of plants was different. More plants were preserved on raised-bed sowing: 96.0 % had “Asyl” variety, 92.4 % had “Intensivnaya” variety. Sowing on stubble was at the second place, where the amount of preserved plants has been made 78.9 % (Intensivnaya), 84.0 – 88.0 (Asyl). Plants preservation on solid sowing was minimal 69.2 – 69.0 %. High plants preservation of 88.0% was on direct sowing into the raised-bed, which left after the maize harvesting.

3.5.4.2 Weed infestation

256. Information is available in the literary data that grass density of winter crops is one of the facts restraining the growth of weeds. Quantitative and specific calculation of weeds showed that during early spring period higher infestation was observed at zero till (Table 6) and has been made 81-87 pcs/m². Weight of weeds in air-dry condition was 204.5 – 235.8 g/m², weight of one plant was at about 2.52 – 2.71 g/plant. Growth focus of rootstock weed of thistle pink (Osot rozoviy) was observed in winter wheat sowing. Availability of burr weed of trailing bindweed (Viunok polevoy) (from 2 to 8 plants) was noted in all the sowing methods. In early spring period minimum infestation was in the experimental variations of raised-bed sowing. Quantity of weeds varied from 45 to 48 pc/m², their weight in air dry condition has been made 124.8 – 109.8 g, weight of 1 plant – 2.60 – 2.44 g/plant. Availability of weeds in the solid sowings was in intermediate values (49-64 pc/m²).

257. It should be pointed out that in current year due to the rainy spring quantity of weeds was almost two times more then in previous year. For this reason on 20 April crops were treated with herbicide “Istrebitel” at a dosage of 20 g ha⁻¹. Leaf-feeding with fertilizers was carried out in calculation for N30 together with herbicide. Technical efficiency of herbicide has made

68.4 %. In general weeds of cruciferous family died. Permanent rootstock weeds have only hampered their growth.

258. Growth of weeds occurred in winter crops during the vegetation period due to the late spring weeds (lambs' quarters, spiny cocklebur, green amaranth). While comparing solid and raised-bed sowing it should be pointed out that in the both varieties on raised-bed sowing quantity of weeds was a bit less than on solid sowing. However weight of weeds by 15/VI increased and has been made 2.48 – 2.26 g/plant. This means that sown part of raised-bed provokes the growth of weed plants. At solid sowing number of weeds after chemical treatment reduced to 40 pc/m², their weight was less and has been made 1.62 g/plant in the sowings of “Asyl” variety and 1.48 g/plant in the sowings of wheat “Intensivnaya”, that is less than spring rates for 66.0– 58.7 %. We explain this by denser grass standing of winter crops which after earing begins to depress weed plants.

259. Higher infestation as in last year was observed at a zero till. Although total mass of weeds a bit reduced due to the chemical weeding, weight of one plant remained a bit high: 3.65 – 3.44 g/plant (Table 6). Besides that, affection by dodder (*povilika*) was observed in these experimental variations.

260. Observations for dynamics of pests' amount and for affection degree of diseases were carried out in winter crops. Single specimen of bread beetle, bread ground beetle, grain bugs were observed on the grain crops. Their quantity did not reach a harmful level and did not have economical value. Considerable affection of grain and cereal crops by helminthosporioz, rust and band was not observed. It is recommended to carry out qualitative treatment of seeds material.

3.5.4.3 Determination of yield

261. Yield measuring was done on 12 July by the direct combining. The following results were obtained: (hopper weight)

Winter wheat “Asyl”	farmer’s practice – 40.2 c ha ⁻¹
	Raised-bed sowing – 52.0 c ha ⁻¹
	Zero-tillage– 34.2 c ha ⁻¹
Winter wheat “Intensivnaya”	farmer’s practice – 36.8 c ha ⁻¹
	Raised-bed sowing – 54.8 2 ha ⁻¹
	Zero-tillage – 30.3 c ha ⁻¹
Winter wheat “Asyl”	Zero-tillage after maize – 46.8 c ha ⁻¹ .

262. Maximum yield gave both varieties at raised-bed sowing. Minimum was at zero sowing.

263. Reap samples were taken for determining the yield structure before grains harvesting. During harvesting samples of grain were taken for determining infestation and moisture. Data will be provided after analysis completion.

3.5.4.4 Soil analyses

264. Soil investigations carried out at the given site in autumn 2008 showed that soil environment's reaction is alkaline pH 8.37, content of mobile forms of nitrogen and phosphorous is low, calcium is average (Table 35). Recommendations were done for increasing dosage of nitrogen to 90 kg ha⁻¹, phosphorous to 90 – 120 kg ha⁻¹. In fact during the current year the dosage of nitrogen has made 74 kg ha⁻¹, phosphorous – 60 kg ha⁻¹.

Table 35. Content of feeding elements in the winter crops sowings (field № 4)

Experimental variation	Content of NPK mg kg ⁻¹ of soils						
	Soil layer, cm	25/IV booting			10/VII before harvesting		
		N-NO ₃	P ₂ O ₅	K ₂ O	N-NO ₃	P ₂ O ₅	K ₂ O
Before sowing	0-25	4.3	18.2	291			
(average sample)	25-50	2.6	10.5	204			
Winter wheat "Asyl"							
- farmer's practice	0-25	12.8	24.2	294	4.2	14.6	290
	25-50	8.4	18.4	220	2.0	9.2	210
- raised-bed sowing	0-25	12.6	26.8	280	1.8	16.2	275
	25-50	8.4	14.0	214	trace	4.0	202
- zero sowing	0-25	13.6	28.2	278	3.6	18.2	254
	25-50	7.0	14.4	202	2.2	12.4	202
Winter wheat "Intensivnaya"							
- farmer's practice	0-25	12.6	28.4	302	3.8	16.8	285
	25-50	8.2	16.6	234	2.2	7.2	220
- raised-bed sowing	0-25	12.8	28.0	287	2.0	16.4	270
	25-50	7.4	16.0	224	trace	6.0	220
- zero sowing	0-25	13.8	28.4	270	2.8	16.8	270
	25-50	6.2	13.2	212	trace	12.8	202

265. Spring determination of movable feeding elements showed that during booting phase after treatment content of nitrogen and phosphorous increased and was at a range of: nitrogen – 12.6 – 13.8 mg kg⁻¹ of soil (in the layer of 0-25 cm), phosphorous was 24.2 – 28.8 mg kg⁻¹, higher content of elements was in the experimental version of zero till in both varieties. Probably on puddle soils these elements are used by plants in less quantity. Intensive usage of all feeding elements was observed at appropriate moisture supply during the vegetation period. As a result of which nitrogen content suddenly reduced, in particular at raised-bed sowing (for

85-85%). Phosphorous was also used intensively. Considerable changes did not occur in calcium regime.

3.5.5 Preliminary conclusions

266. Research carried out during two years showed that both varieties have good reaction on raised-bed sowing, which increases yield for 29.3 – 40.9 % in comparison with existing practice. Besides that, 50% of seeds are saved at raised-bed sowing. Grain crops sowing into the non tillage soil on heave loam requires further clarification due to increasing of soil infestation and non qualitative seeds placement.

3.6 Kyrgyzstan: Activity 2. Study the effect of different herbicide molecules (pre- and post-emergence) on weed dynamics and water productivity

3.6.1 Introduction

3.6.2 Objective

267. The objective of this activity was to determine the efficiency of pre- and after germinated herbicides and their influence on weeds population.

268. Task: To investigate dynamics of weed plants according to specific and quantitative indicators.

3.6.3 Materials and Methods

3.6.3.1 Experiment scheme

269. Research are carried out in maize sowings (field № 1). Application terms of herbicides of various action spectrum are studied according to the scheme:

1. Without herbicides application (manual weeding)
2. Application of pre-germinated herbicides
3. Application of herbicides on vegetated plants
4. Application of pre- and after germinated herbicides

270. Two herbicides are studied with various components (Figure 34).

Figure 34. Plan of experiment arrangements in field № 1 (maize)

Farmer's practice	Pre-germination application. Stomp 5.0 lha-1	After germination application Dialen 1lha-1	Pre-and before germination application Stomp+Dialen
Without herbicides	Esteron 0.6 lha-1	Titus 40 gha-1	Esteron +Titus

271. Maize sowing was carried out by raised-bed planter on 10 May 2009 with hybrid “Ala-Too” breeding of Kyrgyz NII agriculture. Sowing rate is 25-30 kg ha⁻¹. At sowing were applied ammonium phosphate fertilizers in calculation of N13P57 kg ha⁻¹. Raised-bed planter was demonstrated to the heads of neighbor farms during sowing process. After sowing on 12 May 2009 pre- germination herbicides “Esteron” were applied at the dosage of 0.6 l ha⁻¹ and “Stomp” at the dosage of 5.0 l ha⁻¹.

272. On vegetated plants were applied herbicides “Dialen” in the dosage of 1 l ha⁻¹ and “Titus” - 40 g ha⁻¹ in the phase of six real leaves. Herbicides were applied manually in the experimental variations of raised-bed sowing of maize. Selection of herbicides was done coming out from the imported to the republic drugs and their selective effect. Stomp has in its base pendimetaline, effect spectrum is annual cereals and dicotyledonous weeds.

273. Esteron has active ether form 2.4 D (systemic), effect spectrum is dicotyledonous late weeds, from permanent plants: trailing bindweed, dandelion, thistles, tatarian prickly lettuce. Dialen – reactant dikamba + 2.4 D dimethylamine salt, effect spectrum: annual cereals and dicotyledonous weeds, permanent thistles, bindweed, prickly lettuce. Titus contains rimfulforon, drug imported to the republic recently, effect spectrum has not been fully investigated.

3.6.4 Results and discussion

3.6.4.1 Weed infestation

274. Investigation of weeds specific composition on maize crops showed not considerable availability of cereal weed plants: yellow-foxtail grass, wall barley, oat grass, prickly grass, cook’s-foot grass. Broad-leaved weeds: amaranth simple, lamb’s-quarters, frosted orach, caseweed, field pennycress, chingma abutilon, spiny cocklebur, common purslane. From permanent rhizomatous and offset weeds can be found: trailing bindweed, field sow thistle, bitterling. For the moment of determining the specific composition all weeds were at early stage of development and did not make any certain harm on maize crops. Seeds reserves of weeds were determined at the site before carrying out the experiment (Table 36).

Table 36. Seeds stock of weeds at the experiment site in the layer of 0-20 cm.

Precursor	Seeds quantity of weeds million pcha-1					
	T. 1	T. 2	T. 3	T. 4	T. 5	Average
Grains, 4 years	128.8	140.2	137.5	124.8	133.5	132.9
Tilled/grain crops	112.4	105.8	102.2	105.5	116.4	108.4

275. Seeds stocks of weed plants depended on precursor. At four years of grain standing were formed 132.9 million pc ha⁻¹, at alternation of grain and tilled crops - 108.4 million pc ha⁻¹. These numbers mean that during vegetation in conditions of appropriate moisture and irrigation, crops will be constantly subjected to infestation.

276. In spring herbicides were applied according to the experiment scheme. Calculation of weeds was carried out in 5 points of plot by the envelop method. Efficiency of herbicides was calculated by comparing weeds quantity before applying and in each 10 days after herbicides application (Table 37).

277. Observations showed that manual weeding fully destroys vegetated part of the plant, but in irrigation conditions weeds growths again and begin to depress the growth of a main crop.

Application of herbicides before germination protects maize shoots during first 15-20 days, but after that late spring weeds begin to grow which are in conditions of enough moisture supply catch up with maize. In the current year by 20 June efficiency of pre-germination has been made 51.02 – 46.93 %, that is a bit less then last year data (Table 37). Application of after germination herbicides was even less effective 49.1–37.2%. At double treatment with herbicides maize plants are protected during 40-50 days. For this period maize has 30-40 cm height and depresses the growth of weeds. Efficiency of herbicides at doubled application has been made 62.2 – 61.4 %.

Table 37. Efficiency of herbicides on maize crops. (field № 1)

Experimental variations	Quantity of weeds before treatment, pc. m ²	20/VI-09		10/VII-09	
		After treatment			
		Amount of weeds	Technical efficiency of herbicides %	Amount of weeds	Technical efficiency of herbicides %
1. Farmer's practice (manual weeding)	50	25	-	32	-
2. Stomp 5 lha-1 before germination	49	24	51.02	26	46.9
3. Esteron 0.6 lha-1 before germination	49	26	46.93	24	51.0
4. Dialen 1 lha-1 on germination	55	28	49.1	24	45.6
5. Titus 40 gha-1 on germination	51	32	37.25	22	56.8
6. Stomp + dialen	58	21	62.2	10	82.7
7. Esteron+titus	57	22	61.4	14	75.4

278. It is necessary to point out that technical efficiency of all experimental variations is less then last year. This is connected to the climatic conditions of the year. At abundant precipitations which were recorded in April and May, water cycle of plants increases that brings to the reduction of herbicide efficiency.

279. Further efficiency of pre-germination herbicides reduced to 46 – 51 % and at application of Dialen on germinations in the dosage of 1 l ha⁻¹ - 45.6 %. At doubled treatment by 10 July technical efficiency of herbicides increased and was maximal – 82.7 % at application of pre-germination herbicides Stomp 5 l ha⁻¹ and during vegetation period – Dialen – 1 l ha⁻¹ (Table 37).

3.6.4.2 Soil analyses

280. Soil samples on maize crops were taken before sowing on 25 April and during the period of intensive growth on 10 July. Samples were taken from 5 points of plots by the envelope method (Table 38).

281. After fertilizers' application during pre-sowing treatment content of feeding elements was at a range of average value: in plough-layer nitrogen contained 16.8 mg kg⁻¹, phosphorous – 25.5 mg kg⁻¹, calcium - 293 mg kg⁻¹, in sub plough-layer correspondingly: 11.2, 14.5, 274 mg kg⁻¹ of soil. During the period of growth maize intensively used feeding elements, especially nitrogen and phosphorous. In spite of extra nutrient of ammoniac nitrate content of nitrogen reduced in plough-layer for 15 – 28 %, in sub plough-layer for 11.2 – 24.4 %. Nitrogen was used more intensively in the variation where herbicides were applied on vegetated plants. Reduction of phosphoric acid content has been made in plough-layer 19.7 – 36.5 %, in sub plough-layer 17.9 - 28.3 %. Phosphorous was intensively used in the variation where maize was cultivated by farmer's technology.

Table 38. Content of feeding elements in maize crops.

Date of taking sample	Treatments	Soil layers, cm	Content of NPK, mg kg ⁻¹ of soil		
			N-NO ₃	P ₂ O ₅	K ₂ O
25/IV	Before sowing	0-25	16.8	25.5	293
		25-50	11.2	14.5	274
10/VII	Farmer's practice	0-25	13.6	16.2	285
		25-50	9.8	10.8	280
	Herbicides before germination	0-25	12.4	18.2	290
		25-50	9.2	10.4	274
	Herbicides on germination	0-25	11.8	20.5	290
		25-50	8.5	11.8	270
	Herbicides before and after germinations	0-25	14.6	17.4	282
		25-50	10.0	12.2	274

3.6.5 Preliminary conclusions

282. In conditions of redundant moisture the efficiency of herbicides reduces, in particular at application before the germinations. In case of breaking the technology of maize cultivation (that was noted in 2008) doubled application of herbicides can provoke delay of maize growth and development that would reduce the yield for 18-20 %. Research should be continued with another set of herbicides.

3.7 Kyrgyzstan: Activity 3. Study the effect of controlled irrigation methods for improving crop-water productivity, and reduce irrigation-induced soil erosion

3.7.1 Introduction

283. In conditions of water resources shortage increasing and occurrence of surface flow during irrigation, that cause soil erosion on the lands of foothills in Chuyskaya province of Kyrgyzstan, new conceptual decisions for rational usage of irrigation water and for protection the slopes from irrigational erosion are required on the base of water saving irrigation technologies. Intensity and sizes of erosion, reduction of soil fertility, and big consumption of irrigation water depend not only on combination and interaction of natural factors but also substantially on production activity of people.

3.7.2 Objective

284. Creation and introduction erosion-preventive water saving techniques and irrigation technologies, technical facilities for water accounting and normalized water allocation in foothills area of Chuyskaya province, which help to solve the intensification tasks of irrigation agriculture: to use water and labor resources economically; to speed up the fertility reproduction of new and old developed lands with big slopes; to reduce material and labor costs for agriculture products' production.

285. Problem solving on working out the complex of agro technical and reclamation activities for improvement of techniques, irrigation technology and basis of soil protection against erosion are contemplated in this Project.

3.7.3 Materials and methods

3.7.3.1 Natural economical conditions

286. Research is carried out with Kyrgyz scientific-research irrigation institute in accordance with ICARDA Project's subject matter. Pilot farm "Kenenbay" is located on the territory of ail okmotu "Orok" in Sokulukskiy district of Chuyskaya province.

287. According to its soil and climatic conditions the territory of farm is a representative of all foothills zone of Chuyskaya province and refers to the moderate hot continental zone and characterized by the data of Frunzenskaya weather station.

288. Average annual permanent air temperature is + 9.2° C. Annual amount of precipitation varies within the range of 310 – 490 mm. Maximum amount of precipitation falls in spring months April and May.

289. On farm's territory 3 types of soil are singled out: types of chestnut soils with subtype of light chestnut and ordinary grey desert soil (sierozem). According to its mechanical composition soil refers to a heave and middle loamy differences. Soils have little amount of nitrogen and phosphorous, calcium is according to the standards. Humus content varies from 0.88 to 1.66 % at experiment site, and from 0.72 to 1.26 at control site (Table 39).

Table 39. Content of nutrient elements and humus at 0-60 cm layer at experiment and control sites (October 2007)

№	Layers cm	Nutrient elements, mg kg ⁻¹				Humus, in %
		N _{NH4}	N _{NO3}	P ₂ O ₅	K ₂ O	
Experiment site						
1	0-20	0.34	5.47	2.75	220.26	1.66
2	20-40	1.53	1.53	1.13	146.72	0.91
3	40-60	1.86	4.56	1.68	153.5	0.88
Control site						
4	0-20	0,70	2.53	2.80	157.0	1.26
5	20-40	no	0.51	1.14	79.72	0.99
6	40-60	no	0.26	1.14	34.40	0.72

290. Groundwater are free-saline, laid at the depth of 10 and more meters. Farm's lands connected to the system of the Ala Archa river and at present time are irrigated from "Tush" canal. Absolute marks of the site are 745 – 1100. General slop is to the north. In order to achieve the given purpose, 2 experimental variations were carried out for investigations:

291. *First experimental variation* - multiple-factor treatment with using new water saving irrigation technologies and agro technical methods of lands' cultivation at an erosion safe slop equal to $i = 0.014$.

292. *Second experimental variation* – control for comparing with traditional methods of irrigation technologies and agro techniques for lands' cultivation at the erosion causing slop equal to $i = 0.06$.

3.7.3.2 Methods

293. Methodology of investigations is based on the principles which answer to the aimed purpose of planning experiment in the laboratory and field conditions, with checking the research results of getting yield in agricultural conditions, data of which are processed according to B.A. Dospekhov's method. In the basis of evaluation of water consumption by plants and yield measuring, methodologies of SANIIRI, ТИИМ (ТИИМСХ) and Kambarov are assumed, taking into account the updating which is applicable for conditions of arid zones of mountain -sub mountain lands of Chuyskaya province for their usage in intensification direction of agriculture.

294. Portable chutes PPL-50 (SANIIRI) with regulated holes at the bottom were used for transportation and normalized water allocation into the furrows at the highest slope. Water rate for the furrows (holes regulation) was defined by volumetric method.

295. Irrigation furrows in the experiment were cut across dominated slope with the smallest slopes of $i = 0.014$. Irrigation furrows in the control were cut along the biggest slope $i = 0.06$. Triangular and trapezoid crossing weirs were used for water accounting.

296. Weighing bottles, drying cabinets and electronic balance were used for soil moisture determination by thermostatic weighing method. Lag speed was measured by the stopwatches, length of furrow by measurement tape. Systematization and analysis of parameters interaction materials of irrigation and irrigation elements technology are processed in the computer.

3.7.4 Research results of 2008, cultivating maize for grain

3.7.4.1 Agro-biological and irrigation methods for soil protection against erosion

297. On existing irrigation network pre-plowing moisture retention irrigation was carried out (15-17.11.07) with irrigation norm of $M = 1500 \text{ m}^3 \text{ ha}^{-1}$. After irrigation moisture content in meter soil layer at the experiment site (18.11.07) was made $2930 \text{ m}^3 \text{ ha}^{-1}$ or 109.7 HB. In the control field at natural spring moistening thanks to the precipitations reserves were made $1373 \text{ m}^3 \text{ ha}^{-1}$ or 51.2 % HB;

298. On the basis of obtained laboratory data of NPK and humus (see Table 1.1), because of their low content, were calculated the necessary norms of fertilizers application - nitrogen, phosphorous and calcium. Calculated amount of fertilizers were applied to the field before plowing (22.11.07): ammonium phosphate – 250 kg ha^{-1} , calcium nitrate – 200 kg ha^{-1} ⁴

299. Soil plowing was carried out (29.11.07) by the tractor DT-75 to the 25-30 cm depth.

300. In early spring soil samples were taken from the experiment and control sites (23.03.08) for defining the initial moisture and NPK content. Moisture content at the experiment sites (plowing in autumn) for 70% more than at the control site. Moisture reserve is correspondingly equal to $3018 \text{ m}^3 \text{ ha}^{-1}$ and $2110 \text{ m}^3 \text{ ha}^{-1}$. Content of nitrogen and phosphorous at the experiment site at the beginning of vegetation season in comparison with initial data (Table 39) increased much and is given in the Table 40.

⁴ Agro technical recommendations for maize cultivation. MCX Kyrgyz SSR, Kyrgyz NII of agriculture. Frunze. 1971. 48p.

Table 40. NPK content (nutrient elements) in 0-30 cm soil layer of experiment site (March 2008)

№	Layers, cm	Nutrient elements, mg kg ⁻¹				
		NH ₄	NO ₃	N _{NO3}	P ₂ O ₅	K ₂ O
1	0-10	-	15.91	3.60	15.90	204.59
2	10-20	-	17.52	3.96	5.84	198.59
3	20-30	28.38	15.36	3.52	2.95	153.66

301. In spring before sowing, repeated cross ploughing and packing (27-28.04.) of the experiment site was carried out by tractor DT – 75 to 25-30 cm depth.



Figure 35. Field activities in 2008

302. From spring 2008 multiple factor experiments were carried out according to the improved technology (crop - maize on the grain). Various experimental variations are considered for improving irrigation techniques and technology at the site. All fields investigations are carried out in triple replication, on area equal to 0.0075 ha at combined crops - maize and common bean (cowpea).

303. The Indian planter was used while sowing (01-02.05.08) maize seeds of “Manas” variety and common bean (cowpea) of “Krasnaya yubka” variety. 40 kg of maize seeds, 10 kg of common bean seeds were spent at the experiment site and occupy the following areas:

a) maize of “Manas” variety - 0.64 ha;

b) maize with common bean - 0.24 ha;

304. 40 kg of ammonium phosphate were applied together with crops.



Figure 36. Field activities in 2008

305. Heavy rain took place on 05.05.08, amount of precipitation has been made 20-25 mm. During the next days, upper parts of soils were covered with soil crust as a result of warming and temperature increase to 28°C.



Figure 37. Soil crusts after heavy rain

306. Pre-germination soil surface tillage was carried out by OBP sprinkler (07.05.08) against weeds by herbicides “Stomp” with 3 l ha⁻¹ norm.



Figure 38. Herbicide spraying against weeds

307. Packing of the site for breaking the soil crust was carried out by manual mala (from 10 to 13 May). From 10 to 13 May some maize germination came up.



Figure 39. Manual crust-breaking after the rain



Figure 40. Germination of

308. Soil samples were taken for moisture determination (23.05.08) showed that moisture reserves in the meter layer compose 94 % from HB. Mass germination of maize and common bean (cowpea) was observed from 15 to 20.05.08. Thinning of the young crops of maize and common bean was carried out as well as mechanical removal of remained weeds.



Figure 41. Germination of maize and cowpea

309. Too much effort was made while connecting the lock of portable irrigation chutes of SANIIRI, because chutes were defective.



Figure 42. Mounting the plastic chutes for irrigation



Figure 43. Not matching ends of two plastic chutes cause great losses during the irrigation process



Figure 44. Irrigation chute in maize field, 2008

310. With the purpose of hermetic and rigid connection, irrigation chutes were placed from furrows' head, joints of chutes were put as close as possible (by adding ground) for reducing the spacing and strong leakage. To prevent leakage fully was not possible that is why during irrigation, at the places of chutes joining, moistening and washout of soil took place under the chutes. Constant control and adding the ground at the joints take too much time, and also bring to zero all positive indications of chutes. We think that while manufacturing of chutes there was mistake in the technological process, as a result of which chutes parameters changes at the joint place.



Figure 45. Plastic chutes control irrigation and reduce water-induced erosion

311. Regulation of water outlets for allocating the calculated rate, elimination of leakages at joints, and also preparation of necessary equipment (weirs, stopwatches, measurement tape, measuring glasses, bottles for water withdrawal for turbidity etc.) are carried out before each irrigation.

312. After 6-7 leaves coming up, mineral fertilizers urea was applied in the amount of 100 kg ha⁻¹ (25.06.08). First irrigation was done (20.06.08) in irrigation norm of 600 m³ ha⁻¹. The next vegetation irrigations were carried out when pre-irrigation threshold equal to 0.7 HB was reduced: the second irrigation was made on 05.07.08 with irrigation norm of 600 m³ ha⁻¹; the third was on 17.07.08 with irrigation norm of 650 m³ ha⁻¹; the fourth was on 29.08.08 with irrigation norm of 650 m³ ha⁻¹; the fifth was on 13.08.08 with irrigation norm of 650 m³ ha⁻¹.

313. On 13.09.08 common bean crops were harvested. On 23.09.08 maize crops were harvested.

314. Observations were carried out at various water rates (0.1 l/sec, 0.2 l/sec, 0.3 l/sec) for: speed of entering the last point of furrow, washout of furrows, discharge at the end of furrow, evenness of moisture along the length of furrow etc.

315. After germination treatment with herbicide “Dialen” (30.06.2008) with 3 l ha⁻¹ consumption was carried out for weed control. Field treatment with herbicide helped to exterminate all weed plants for 90%. However during next irrigations seeds of weeds (which have not grown before) recommenced their germination on the irrigated fields, weed control was carried out by mechanical method.

316. On the photo weeds looking 2 days (02.07.08) after treatment with “Dialen”. Samples taken for NPK after harvesting are given in the Table 41.



Figure 46. After treatment with herbicide “Dialen



Figure 47. Weeds residues at the end of vegetation (11.09.08)

Table 41. Content of nutrient elements in 0-60 cm soil layer at the experiment and control sites (October 2008)

№	Layers, cm	Nutrient elements, mg kg-1				
		NH ₄	NO ₃	N _{NO3}	P ₂ O ₅	K ₂ O
Experiment site						
1	0-20	-	56.38	12.74	4.51	237.02
2	20-40	-	49.08	11.10	3.99	251.14
3	40-60	-	45.66	10.32	2.85	273.97
Control site						
4	0-20	-	35.09	7.93	1.17	234.19
5	20-40	-	17.67	3.99	-	153.00
6	40-60	-	2.41	0.54	-	94.12

3.7.5 Soil protection against erosion by improving the elements of irrigation techniques

3.7.5.1 Reasons of formation and occurrence of irrigation erosion

317. Irrigation erosion which emerges under the activity of irrigation waters appears as a retrogression of canals, demolition of the structures on them and soil washout during the irrigation which is made directly from field.

318. Detailed consideration of the reason of irrigation erosion processes occurrence showed that it is stipulated by relief (big slopes in the area, horizontal ruggedness and tillage of the territory, availability of a number of slopes at the same irrigation site), soil conditions (type of soil, their hydro-physical features and mechanical composition), plant cover and also organizational economical activities of human being. In relation to this the main prerequisites for development of irrigation erosion are: wrong arrangement of the irrigation site territory; bad leveling of field surfaces; low level of agro techniques for agricultural crop cultivation; absence of modern engineering irrigation network on the considerable area of irrigated lands; construction of irrigation network with not acceptable slopes; absence of discharge network in the majority of systems, as a result of which water escape is made to the nearest beams and ravines without preliminary installation of erosion-preventive structures; discrepancy of irrigation techniques elements (length of furrow and water rate for furrow) to the slopes of irrigated sites; wrong arrangement of field works; non development and in number of cases neglect of erosion-protective technological activities.

319. At least in one example it should be pointed out to which negative consequences can lead washout of irrigation furrow in case of not following the optimal water rate for the furrow. Agro technical soil tillage after irrigation becomes difficult because at a deep gully knives of cultivator do not reach the bottom of furrow as a result of which hoeing quality reduces; soil is

moistened only below the gully, and at above position raised-beds of furrows remain dry. Repeated furrow cutting make them worse because creates better conditions for erosion; applied fertilizers are removed by water flow without being used by plants.

320. Results of field experiments show that surface irrigation in any conditions (soil, slop) irrespective of irrigation techniques elements, washout and soil particle transport take place in any case beginning from the slope of 0.007 inclinations. Obviously that absolute prevention of erosion is not possible. Meanwhile with appropriate regulation of water rate for the furrow and other elements of irrigation techniques and technology it is possible to minimize erosion and its negative influence on soil productivity and therefore on crops productivity.

3.7.5.2 Soil protection against erosion by changing the slops and direction of irrigation furrow

321. Irrigation method into furrows still dominates in foothills zone. This is a bit laborious process of moisture supply to irrigated lands. That is why in order to provide a high efficiency of plants moistening it is necessary to create perfect systems for furrow irrigation, usage of which would improve irrigation technology of slope lands and would become the basis for obtaining stable and rich crops yield and also would be a reliable soil protection against irrigation erosion. In this relation, concept of erosion control is the selection of optimal values of irrigation techniques elements and erosion secure direction and slope of irrigation furrow applicable to the specific slope relief.

322. In conditions of high slopes (0.007...0.10) in foothill zones surface irrigation will be effective if improved elements of furrow irrigation techniques are used - this is the irrigation along deep short furrows with irrigation technology - through furrow and by normalized alternate water supply into the furrow.

323. Irrigation to the furrows on its own account is ecologically clean, provides deeper soil moistening. During irrigation soil moistens in the period of water movement along furrow with relatively less rate ($q = 0.1 \dots 0.3$ l/sec), water goes into the soil mainly by capillary method, i.e. infiltrates by profile. Method of furrow irrigation enables the usage of mechanisms on raised-bed soil tillage, providing good aeration inside the soil (content of ventilated air in the soil, as during irrigation raised-beds between furrows remain relatively dry, this considerably improves air and thermal regime of soil).

324. The main advantage of furrow irrigation is also that soil crust does not form on the raised-bed spaces and it is more economical and rational then other methods of surface irrigation. Technically irrigation norm can be reduced to minimum – 300...500 m³ ha⁻¹ for vegetables; 500...600 m³ ha⁻¹ for tilled crops and 600...800 m³ ha⁻¹ for grain cereals and permanent grasses.

325. Furrows' cutting by mechanisms should be continuous along the whole length of irrigated site and especially qualitative - with following the straightness relatively to the crops

line and clean from earth clods, waste and root residues from the previous growth. Without fulfillment of these requirements it is very difficult to carry out effectively the resource saving technologies of normalized water supply and erosion free irrigation on the furrows.

326. At indicated parameters accepted speed of water rate for the furrow should not exceed 0.2...0.3 m/min, at water discharge in the furrow of 0.1...0.3 l/s, and possible value of acceptable soil washout should not exceed 10...15 t ha⁻¹ per year.

3.7.5.3 Soil protection against erosion by regulating the rate of irrigation flow

327. Time of water entering to the end of dry furrow is one of the most important erosion-protective indicators of irrigation techniques elements. Water flow, moving along the bottom of irrigation furrow changes according to the rate and movement speed under the influence of water consumption ability of soil and slope.

328. For cogency two experimental variations of investigations were carried out. The first variant – furrows cut at high slopes ($i = 0.06$) and the second variant - furrows cut at erosion preventive slopes ($i = 0.014$).

329. Determination results of average speed of water movement along the dry furrow (Table 42) depending on studied rates of irrigation flow shows that at the site with big slope flow speed increases from 0,22 up to 1.01 m/min, time of lag reduces almost in 3 times. Thus, time of water entering to the end of furrow at the small slopes is equal to 317 min., and at the big slopes - 106 min.

Table 42. Influence of the speed of irrigation water flow movement on irrigation erosion

Water flow into furrow l/sec, alternate Current	Speed of irrigation current, m/min		Irrigation norm, net/gross m ³ ha-1	Erosion per one irrigation, tha-1	Coefficient of efficiency of irrigation techniques	Maize productivity, cha-1
	Middle of furrow L = 35	End of furrow L = 70				
Experiment $i = 0.014$						
0.1 – 0.05	0.48	0.20	650/774	2.8	0.84	79
0.2 – 0.1	0.21	0.23	650/788	3.4	0.82	
0.3 – 0.2	0.23	0.25	650/754	4.8	0.86	
average					0.84	
Control $i = 0.06$						
0.1 – 0.05	0.69	0.81	650	18.7	0.61	61
0.2 – 0.1	0.81	0.94	650	25.3	0.59	
0.3 – 0.2	0.98	1.05	650	32.2	0.64	
average					0.61	

330. In this relation having considered the methods of improving the techniques for reducing the water entering time at the big slopes we can observe that they do not improve ecological

condition of slopes lands irrigation, but only in some extent reduce soil erosion in comparison with the sites of traditional irrigation. Nevertheless negative results in any case showed that tested activities would give its positive result and effect if upgrading of irrigation techniques and technologies begins from changing the direction of irrigation furrows along the slopes close to contour i.e angularly to the normal relatively to maximum one.

331. In such experimental variation the usage of cross cleft's closing in slopes and contour (slanting) furrows' cutting considerably reduces water movement speed along the whole length of irrigation furrow and time of water entering increases in more then 2 times, speed of flow movement reduces in more then 5 times becoming erosion safe.

332. As for experimental variation with alternate current of water supply into the furrow (reducing it to the value of 2/3 discharge volume), then here becomes evident that rationality of such regime and optimal irrigation technology into the furrows by cutback is fit nicely.

333. Usage of cross cleft's closing influences not only on reducing water movement speed along the whole length of the furrow, but also on reducing the discharge of irrigation water. And as there is no water discharge then there is also no sediment runoff.

3.7.5.4 Soil protection against erosion by regulating the depth and length of irrigation furrow

334. During irrigations to deep furrows on wide-row sowings with availability of middle and big slopes, water that moves along the packed layer of soil makes washout of slopes and furrows' bottoms, - washout depth at big slopes reaches 35 cm, sometimes even up to under laying pebble stoned layer.

335. According to the flow rate $q = 0.10$ l/sec water time for the furrow of 10 cm depth at furrow's length of 70 m at the control with big slope $i = 0.06$ is made 219 min., and at 30 cm depth only 189 min (Table 43). Together with this, at the experiment i.e. at the small slops with resource saving irrigation technology time of water entering the end of furrow is made 466 and 438 min. By increasing of irrigation flow, for example up to 0.3 l/sec, time of water entering at the control considerably reduces correspondingly to 111 and 103 min., and at the experiment time of water entering is stable and stays at the level of 310 and 290 min. Discharge of sediment runoff for one irrigation at the control has been made at the range of 28.3 to 31.8 t, and at the experiment was minimum stable, at the range of 4.3...4.8 t per one irrigation.

336. Reducing of water entering speed at shallow irrigation furrows is explained by the availability of mellow layer in furrow perimeter that promotes a better water infiltration of the sides, good moistening of root layer, less movement and discharge of soil particles out of the irrigation cards and at last increasing the productivity of vegetables. Thus, more optimal depth of irrigation furrows at the slope lands is 25...30 cm, and the length of furrow is about 70 m.

Table 43. Influence of furrow's depth and rate of irrigation flow on irrigational soil erosion L bore =70 m

Depth of furrow, cm	Rate of irrigation flow, l/sec	Time of entering till the end of furrow, min	Average speed of water lag along the furrow's sections, m/min			Irrigation norm, m ³ ha-1	Discharge of sediment runoff per one irrigation, tha-1
			0-10	30-35	65-70		
Experiment i = 0.014							
10	0.10	466	0.19	0,19	0.15	731	2.4
15	0.10	411	0.22	0,13	0.17	712	3.2
30	0.10	438	0.21	0,16	0.16	723	3.9
10	0.20	389	0.23	0,15	0.18	650	3.1
15	0.20	363	0.25	0,20	0.19	643	3.6
30	0.20	332	0.27	0,22	0.21	650	4.1
10	0.30	310	0.29	0,22	0.23	670	4.3
15	0.30	317	0.31	0,21	0.22	658	4.6
30	0.30	290	0.35	0,23	0.24	660	4.8
Control i = 0.06							
10	0.10	219	0.81	0,88	0.82	650	9.9
15	0.10	194	0.79	0,85	0.86	669	14.4
30	0.10	189	0.77	0,85	0.87	681	18.5
10	0.20	155	0.88	0,92	0.95	700	19.7
15	0.20	130	0.90	0,96	0.94	693	23.3
30	0.20	125	0.91	0,93	0.96	715	24.5
10	0.30	111	0.90	0,92	0.93	730	28.3
15	0.30	106	0.94	0,91	1.01	725	30.7
30	0.30	103	0.92	0,94	1.05	732	31.8

3.7.6 Results of 2009 for cultivating spring wheat of the variety "Intensivnaya" (first reproduction)

3.7.6.1 Preparation of irrigation site for the sowings and vegetation irrigation

337. Ploughing at the experiment site was done on 12.11.08, deep up to 25...30 cm with applying mineral fertilizer ammonium phosphate with norm of 80 kg ha⁻¹ under the tillage.

338. On 24.03.09 agro technical soil tillage was carried out: micro planning – by a heavy mala, harrowing by heavy harrow, deep disking. On 05.04.09 samples were taken for defining the initial moisture and NPK nutrient elements' reserves. On the second day wheat sowing of "Intensivnaya" variety of 1st reproduction was carried out with repeated application of mineral fertilizers "Ammonium phosphate" in calculation for 80 kg ha⁻¹. Sowing was carried out according to the method of sowing furrows by the Indian planter. On 14 -15. 04.09 good and even sprouts of wheat appeared. On 14 -15. 04.09 field was treated with herbicide "Dezormon" with consumption of 1 l ha⁻¹ for weed control. Observations for the soil moisture and for growth and development of the plants were carried all the time during the vegetation period.

339. Spring storm precipitations (according to the data of Belovodskaya weather station is more than 70 mm) made possible to postpone the terms of the first irrigation approximately for 1 month, as participations stayed in cut furrows and effectively were used by the plants with moisture at the level of 0.8HB till the time of the second irrigation. For this reason first planned irrigation was postponed according to the irrigation regime to 21 June. Taking into account the initial moisture reserves one irrigation was done with norm of 750 m³ ha⁻¹. Plan experiments for erosion-prevention activities were carried out during the irrigation.

3.7.6.2 Technical technological results of wheat irrigation on the sowing furrows

340. At the big slopes of more than $i > 0.007$, erosion processes strengthening due to increased norms of water supply and unacceptable speed movement of irrigation flow in the furrow itself.

341. For efficient usage of irrigated area at the high slops and for the purpose of considerable reducing and liquidation of erosion processes, vegetation and pre-emergence irrigation of wheat, alfalfa, annual grasses and other crops of solid sowing is recommended to carry out into the sowing furrows.

342. In fact this is the type of the same irrigation as into the clean not sown furrows, the only difference is that cutting of sowing furrows is carried out, as a rule, together with sowing of narrow rowed crops and crops of solid sowing. For this purpose solid sowing of wheat was carried out by the Indian planter and after that by the second passing of furrower KOR -5.6. Furrows were cut immediately after the sowing. In this case seeds remain not only at the bottom of furrow but also place at the slopes of cut furrows. Together with this it should be pointed out that seeds grow faster than to better contact with soil.

343. Irrigation into the sowing furrows allow to the root systems of plant to fix pit-run fines firmly around the perimeter of sowing furrows. And as experiment showed this is a good erosion-preventive activity for using rational irrigation at big slopes up to $i = 0.10 \dots 0.15$, as the surface part of plants creates an additional roughness in the furrow's perimeter, which causes the obstacles that considerably reduce the speed of water to the furrows, preventing erosion processes and considerably increasing the irrigation quality (Table 45). Quality coefficient of irrigation increases up to 0.98, and co efficiency of efficiency of irrigation techniques up to 0.98, while irrigation for clean furrow showed considerably lower rates – correspondingly equal to 0.69 and 0.57. Together with this there is almost no erosion (Table 44) while irrigation of clean furrow considerably impairs washing out a fertile layer in the amount of 32.7 t ha⁻¹ per one irrigation.

344. Sowing furrows are cut at a distance of 60-70 cm from each other. Water supply is made by increased current up to 0.7...1.0 l/s for each furrow. Thank to optimal moisture supply of the plants for the account of precipitations in spring, the first irrigation in foothills zone will be required in average annual year not earlier than in the middle of June. By that time plants will

get stronger and their root system will firmly resist erosion processes during irrigations and intensive precipitations (Figure 48).

345. Thus, the advantages of crops irrigation of solid sowing into the sown furrows are as follows:

- Irrigation water economy (to 30%);
- Increasing of irrigation evenness at the site to 98%;
- Possibility of optimal matching of irrigation techniques elements and irrigation elements by arranging appropriate distance between furrow;
- Providing the usage of technical facilities of small mechanization;
- Improving the work conditions of irrigator and increasing its productivity;
- Providing the unity of irrigation techniques of all crop rotations at their replacement (rotation) at the irrigated site, that guarantees applicability of unity and one type irrigation techniques.



Figure 48. Wheat irrigation into the sowing furrows

Table 44. Detection of irrigation erosion during wheat irrigation according to the technology of sowing furrow

Experimental variations	Irrigation technology	Types of slopes, i	Irrigation rate, m ³ ha-1	Length of furrow, m	Water turbidity, kg/m ³	Erosion per one irrigation, tha-1
1-spring wheat	Sowing furrow	0.014	735/750	80	traces	-
2-spring wheat	Sowing furrow	0.06	735/750	80	traces	-
3-spring wheat	Clean furrow	0.06	735/1290	80	6.7	32.7

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Table 45. Irrigation quality in sowing furrows at cultivation of spring wheat of “Intensivnaya” variety

Crop	Irrigation method	Replication	Water intake into the furrow, l/sec	Length of furrow, m	Slope, i	Irrigation rate, net/gross	Efficiency of irrigation techniques	Moisture reserves in 0-80 soil layer, m ³ ha-1		Irrigation quality K _п =W _к : W _н	Wheat yield, cha-1
								Wend of bore	Wbegin. bore		
Spring wheat	Sowing furrow	1	0.7	80	0.014	735/750	0.98	1870	1910	0.98	
		2	0.7	80	0.014	735/750	0.98	1860	1890	0.98	
		3	0.7	80	0.014	735/750	0.98	1880	1920	0.98	
	Average									0.98	43
Spring wheat	Sowing furrow	1	0.7	80	0.06	735/770	0.95	2050	2135	0.96	
		2	0.7	80	0.06	735/770	0.95	2170	2237	0.97	
		3	0.7	80	0.06	735/770	0.95	2090	2133	0.98	
	Average									0.97	41
Spring wheat	Sowing furrow	1	0.7	80	0.06	735/1290	0.57	2130	3179	0.68	
		2	0.7	80	0.06	735/1290	0.57	2210	3113	0.71	
		3	0.7	80	0.06	735/1290	0.57	2105	3096	0.68	
	Average									0.69	30

3.7.7 Conclusions

346. On the soils with slopes from 0.007 and higher, at any rates of irrigation flow can be observed the irrigation erosion. As a result of this degradation and depletion of humus and gross forms of nitrogen and phosphorous took place due to the sediment runoff discharge in the zone of washout and ablation.

347. On the heavy reclamation lands of foothills were worked out staged principles of soil tillage, irrigation techniques with using a complex of reclamation, agro technical activities for preventing or considerable reducing of erosion processes and for increasing the fertility of slope lands.

348. Effective methods for irrigation erosion control are as follows:

349. deep to 30 cm plowing across the slope; harrowing by heavy harrows, disks; maize sowing in two lines;

350. on maize crops is recommended to change the direction of irrigation furrow - from dominated dip along the slope to the given (0.005...0.007) erosion secure dip, directed across the slope. While cultivating grains and cereals is recommended to carry out the solid sowing with irrigating the furrows. At the slop of $i = 0.15$ is recommended to cut furrows to the direction of dominated slop, as at such slop erosion processes do not appear. Irrigation coefficient will be 0.98, i.e. in fact evenness of moistening is 100% with irrigation efficiency of 0.98%. Water intake to the furrow is possible till 1 l/sec. Optimal length of irrigation furrow depending on micro relief is till 80 m. Depth of furrow placement is 0.25 cm. Head water intake into the furrow is $q = 0.2...0.3$ l/sec. Acceptable average speed of water course in not matted furrow should not exceed 25 cm/min. Irrigation of maize is carried out through furrow.

351. water accounting should be done at the border of water allocation to the farm by trapezoid weir Chipoletti, and inside the farm by triangular weir Thomson. Normalized water distribution is carried out by polyethylene tubes, bottles of mineral water and napkins.

352. following the recommended water saving techniques and technologies enabled to reduce erosion processes in the irrigations on clean furrow in more then 8 times and reduce soil erosion from 31.8 t ha^{-1} to quite acceptable – 3.9 t ha^{-1} per one irrigation. In the irrigations on sowing furrows is possible (till the dip $i = 0.1$) to prevent totally erosion of slope lands.

353. Maize yield in comparison with control increased for 23% and has been made 79 c ha^{-1} , and wheat yield increased for 31% and has been made $41...43 \text{ c ha}^{-1}$.

3.8 Kyrgyzstan: Activity 4. Effect of conjunctive use of fresh and drainage water on crop yields and soil salinity build-up

3.8.1 Introduction

3.8.2 Objective

354. The objective of this activity was to determine the possibility of using drainage water for productivity and its quality. The experiment was carried out in the field №1 of maize crops. The following variants are studied in the experiment:

1. Usage of clean water.
2. Usage of drainage water.
3. Combining clean and drainage water in ratio 1:1.

3.8.3 Materials and methods

355. Irrigations are assigned according to the moisture of the soil with using facilities for water allocation and accounting.

356. The following works were carried out during the reporting period:

357. place and sizes of board-gate were determined which are planned to install on the derivation of water-distributing canal for creating backup and diversion flow in the field of farm “Daniyar”. Size of boards is 80x80 cm.

358. Preliminary negotiations were held with manufacturers of board-gates and after measuring the structure manufacturer prepared an agreement for board-gates manufacturing. Gates were installed together with WUA (Figure 33 and Figure 49).

359. Necessary equipment was bought for calculation of irrigation water which comes to the farm’s field:

- Portable weir Chipolletti and head;
- Triangular Thomson weir

360. Pre-irrigation soil moisture was determined. Soil selection was done from 4 points from layers – 0-20, 20-40, 40-60, 60-80, 80-100 cm. Norm of pre-sowing irrigation was calculated according to the moisture. Water accounting was determined with help of portable weir Chipolletti which is available at “Daniyar” farm. Norm of pre-sowing irrigation is made 1100 m³ ha⁻¹, in fact poured 1000 m³ ha⁻¹.

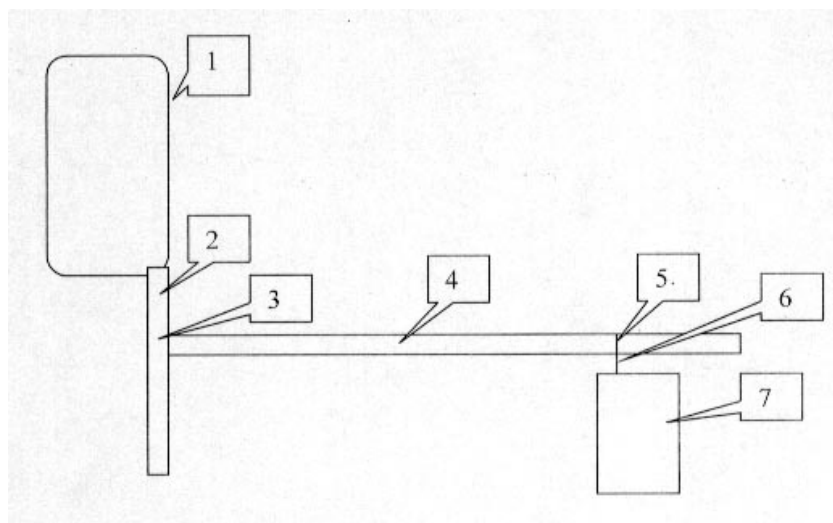


Figure 49. Scheme of farm's irrigational system

- Legend:
- 1 – reservoir
 - 2 – on-farm canal (land bed)
 - 3 – T-bend water apportioning (flat board)
 - 4 – inter-farm canal (land bed)
 - 5 – water distributor in the field (flat board)
 - 6 – weir Chipoletti
 - 7 – experimental field

361. Existing reservoir is considered as an irrigation source (Figure 49). Water from reservoir comes into the on-farm canal and from the latter into the inter-farm canal. Water intake in the field was carried out from inter-farm distributor. And at the point of water outlet water account was carried out through the temporary (intake) sprinkler which is regulated by trapezoid weir Chipoletti. Distance from reservoir to experiment site is 700 m. Distribution to the irrigation furrow was done through the vent furrow regulated by triangular Tomson weir.

3.8.4 Results and discussion

362. In spring period collector drainage waters were used in the experiment 4. In relation to this water samples were taken for determination of their chemical composition. The following results were obtained as a result of chemical water analysis by water taking:

- Mineralization of drainage water is 1.19 g l-1;
- Mineralization of ground water is 1.29 g l-1;
- Type of mineralization is sulphate- hydrocarbonate

363. According to the results conclusion can be made that water is applicable for irrigation.

364. Observation of groundwater table. Experiment site is located in a zone of shallow groundwater level. At determining irrigation norm for crops it is necessary to take into account feeding from groundwater. For observing the level of groundwaters at the beginning of April 2

were installed two observation wells with 2 m depth at the beginning (1 well) and at the end of experiment site (1 well). Aluminum pipes with diameter of 40 mm were installed as the well (photos 7, 8). Measurement of the ground water level is carried out with a help of polyethylene pipe with 15 mm diameter which is lowered to the well. After that length of damped pipe is measured by measuring tape. Measurements are made twice per month (Table 46).

Table 46. Dynamics of Groundwater' level (cm) in wells

Number of wells	Date of observation						
	4.04.09	18.04.09	02.05.09	16.05.09	30.05.09	13.06.09	27.06.09
1	175	166	168	157	148	152	121
2	165	157	158	149	143	144	111

365. Irrigation of maize crops was carried out at the experiment site on 26 June, as a result of which level of groundwater raised up to 111 – 121 cm. Observations will be continued after each irrigation. For the reason that research of previous years confirmed the possibility of using drainage waters, irrigations in 2009 were carried out directly from the reservoir. Irrigation was done on 26 – 28 June, terms of irrigation were postponed due to the abundant of precipitation, pre-irrigation moisture turned out to be high (Table 47).

Table 47. Dynamics of soil moisture in meter layer (% from dry soil mass)

Number of points	Month, decade					
	May			June		
	I	II	III	I	II	III
1	21.3	20.4	19.4	19.2	17.5	16.0
2	20.4	20.2	18.9	18.7	17.4	15.8
3	20.3	19.6	18.4	17.8	17.3	15.6

366. During irrigation rate for each furrow has been made 0.35 l/sec., duration of irrigation was 5 hours. Irrigation norm is 650 m³ ha⁻¹. Length of each experiment site is 100 m. Width is 4.2 m. Total area is 420 m². Width of raised-beds in irrigation furrows is 0.7 m.

367. Discharge furrows are cut across the irrigation furrows with 20-25 cm depth into the cut-and-fill in order to be commanded by them and to create a zero slope. Length of discharge furrows has been made 4.2 m that was enough for serving 6 irrigation furrows at the same time. Discharge furrows were laid at zero slope that gave the chance to equal water allocation into the heads of each irrigation furrow. Trapezoid weir Chipoletti is installed in the head of temporary sprinkler for water accounting at the site.

368. Irrigation rates through trapezoid spillway was determined according to the formula:

$$Q = 1,86 \times B \times H^{3/2}, \text{ m}^3/\text{sec}$$

where, B – width of weir in meters (in our case 0.4 m); and H – water head over weir, m.

369. Such kind of weir was installed also at the end of experiment site for discharge water accounting. Regulation of water rate for the furrow was carried out by technical facilities of small mechanization of surface irrigation - triangular weir Thomson. Irrigation rate through triangular weir Thomson was determined according to the formula:

$$Q = 1,4 \times H^{2.5}, \text{ m}^3/\text{sec}$$

where, H – water head over weir, m.

370. Second irrigation of maize was carried out on 10 July. Rate for the furrow has been made 0.35 l/sec, duration of irrigation was 4.5 hours, and irrigation norm was 700 m³ ha⁻¹.

3.8.5 Preliminary conclusions

371. Mineralization of drainage water is not high which allows using it for irrigation. It is necessary to control the soil processes during 3-4 vegetation seasons, as mineralization of groundwater can be increased because of increasing the dosage of fertilizers.

3.9 Kyrgyzstan: Activity 5: Assessment of influence of exact leveling, carried out by laser land leveler on water economy, salinity and crops productivity in irrigated zone

3.9.1 Introduction

372. Investigation is carried out in the field № 2 on soybean crops where in autumn 2008 was carried out laser land leveling at the given slop of 0.007. In spring 2009 repeated field leveling provided the general slop from the south to the north - 0.004.

3.9.2 Objective

373. The objective of this activity was to study irrigation regime of soybean at different water rates into the furrow and water economy.

3.9.3 Tasks of Research (for two treatments)

- selection of furrow length and water rate for each furrow depending on the slop of the area and soil permeability;
- studying a movement of water flow in the furrows (time of entering the last point in the furrow);
- measurement of water rate into the furrow by Tomson weir;
- determination of norms, terms and duration of the irrigations;
- determination of a number of irrigations, irrigation norms and crops productivity at the end of vegetation period;
- economic calculation, comparing efficiency of irrigation water usage.

3.9.4 Materials and Methods

374. Fields experiments are carried out on the lands of farm “Daniyar” in Sokulukskiy district. Soil-reclamation conditions of the site are characterized as: general slop is from the south to the north at the range of 0.004. Relief is still and leveled. Soils are meadow - sierozem. Average volume weight in meter layer of the soil is 1.30 g/cm³ (1.28 g/cm³ in 0-20 cm of the layer, up to 1.43 g/cm³ for profile). Mechanical texture of the soil is middle loamy (0...20 cm), heavy loamy (20...40 cm), clays (40...60 cm), light loamy (60...80 cm), clays (80...100 cm). Groundwater are laid in the depth of 0.7...1.8 m from the ground surface. Minimal moisture capacity in the meter layer of the soil at the average is made 22% from the soil volume weight of 2200 m³ ha⁻¹. Threshold of pre-irrigation moisture capacity is 15.4% (1540 m³ ha⁻¹). Water permeability is middle – 10-12 cm/hour.

375. Preliminary results carried out at the site in autumn 2008 showed that rate for furrow at the range of 0.1 – 0.15 l/sec provides water economy, allows to irrigate without discharge, but increases the duration of irrigation up to 8 – 11 hours (refer to annual Report for 2008).

376. According to the recommendations, the length of experiment site - 100 m and water rate into furrow (0.50 l/sec) was selected according to the average soil permeability (10cm/hour) and area slop (0.004). Width of the experiment site is 6.3 m then total area of the experiment site is 630 m². Width of raised-beds in irrigation furrows has made 0.7 m, amount of experiment furrows is 9 pieces. Experiment replication is triple. Date of soybean sowing is 5 April 2009.

3.9.5 Results and discussion

3.9.5.1 Cutting of discharge furrow

377. Discharge furrows were cut across the irrigation furrows with depth of 20...25 cm into cut-and-fills in order to be commanded by them over irrigated field and for creation of zero slop.

378. Length of discharge furrows has been made 6.3 m that is enough for serving 9 irrigation furrows at once. Distance between irrigation furrows has been made 0.7 m. Discharge furrow were laid at zero slop that gives the chance to equal water allocation for each irrigation furrow. Trapezoid weir Chipoletti is installed at the head of temporary sprinkler for water accounting at the sites. Irrigation rate through trapezoid weir was calculated according to the formula:

$$Q = 1,86 \times B \times H^{3/2}, \text{ m}^3/\text{sec}.$$

where, B – width of weir, m (in our case 0.4 m); and H – water head over weir, m.

379. Normal regulation of water rate into the furrow was carried out by triangular Tomson weir during irrigation. Irrigation rate through triangular Tomson weir was determined according to the formula:

$$Q = 1,4 \times H^{2,5}, \text{ m}^3/\text{sec}.$$

where, H – water head over weir, m.

380. Determination of duration and norms of irrigation. The first irrigation was done on 27 June 2009 during the phase of soybean budding. In the experiment (variation 1) with water supply $q=0.50$ l/sec, average duration of the time of entering the last point in the furrow has been made 3 hours 36 minutes. After stream entering to the end of the furrow, stream flow at the beginning of the furrow reduced to 0.35 l/sec, for the volume of waste to be reduced. Further experiment plots were irrigated for 1.5 hours more with water escape in order to irrigate the endings of furrows. During the indicated total irrigation duration (5 hours 6 minutes), in fact irrigation gross norm has been made 1100 m³ ha⁻¹, net norm - 660 m³ ha⁻¹. Data for irrigation norm at various experimental variations are given in the Table 48. As it is shown in the Table

48 irrigation water moves faster on the leveled surface than on uneven site. The second irrigation is planned on 9 July. Thus, investigations will continue during further irrigations.

**Table 48. Determination of time (t) and speed of irrigation stream entering to the furrow's sections (V).
The first irrigation.**

Experimental variation	Furrows' sections, m	Average for 3 replications			Irrigation gross norm, m ³ ha-1	Volume of water escape, m ³ ha-1	Irrigation net norm, m ³ ha-1
		time, t		Average speed of stream V, m/min			
		h	min				
1 – experiment Irrigation with water escape q=0,50 l/sec	Beginning of irrigation	10	30				
	0-10	11	05	3.5			
	10-50	12	57	2.8			
	50-70	13	25	1.4			
	70-100	14	01	1.2			
Time of entering for 100 m	0-100	3	36	3.36			
Irrigation duration		1	30				
Total irrigation duration		5	06				
					1100	440	660
2 – control Irrigation with water escape q=0,35 l/sec	Beginning of irrigation	10	30				
	0-10	11	06	3.6			
	10-50	13	06	3.0			
	50-70	13	40	1.7			
	70-100	14	22	1.4			
Time of entering for 100 m	0-100	3	52	3.52			
Irrigation duration		2	00				
Total irrigation duration		5	52				
					1260	510	750

3.9.6 Preliminary conclusions

381. At well leveled fields with small rate into the furrow 0.1 – 0.15 l/sec irrigation can be carried out without water escape. For time saving it is possible to increase water rate into the furrow up to 0.35-0.50 l/sec at this slop without consequences of irrigational erosion.

3.10 Kyrgyzstan: Activity 6. Calibration and usage of the optical sensor “Greenseeker”

3.10.1 Introduction

3.10.2 Materials and Methods

382. The following work was carried out in 2009. In April experience for calibration a signaling device Greenseeker was implemented on the winter wheat crops in 6 variants and 3 replications. Treatments of nitrogen fertilizers with application norm of 0, 30, 45, 60, 75, 90 kg ha⁻¹. Plot area is 15 m². Measurement of NDVI data was carried out by Greenseeker on the crops every week.

3.10.3 Results and discussion

383. NDVI data is given in the Table 49, and NDVI registrations' schedule is shown in the Figure 50.

Table 49. NDVI data at the experiment site according to the calibration of Greenseeker

Registration	Experimental variation					
	N0	N30	N45	N60	N75	N90
04.04.09	0.13	0.13	0.13	0.14	0.11	0.13
12.04.09	0.14	0.14	0.15	0.15	0.13	0.15
18.04.09	0.37	0.35	0.39	0.48	0.42	0.39
26.04.09	0.37	0.35	0.39	0.48	0.42	0.39
03.05.09	0.45	0.43	0.44	0.53	0.48	0.46
10.05.09	0.69	0.68	0.69	0.76	0.73	0.72
16.05.09	0.69	0.70	0.70	0.71	0.73	0.76
24.05.09	0.66	0.68	0.72	0.74	0.74	0.76
30.05.09	0.65	0.66	0.68	0.70	0.71	0.71
06.06.09	0.64	0.67	0.65	0.70	0.70	0.70
13.06.09	0.62	0.65	0.63	0.69	0.67	0.66
20.06.09	0.36	0.35	0.37	0.38	0.41	0.38

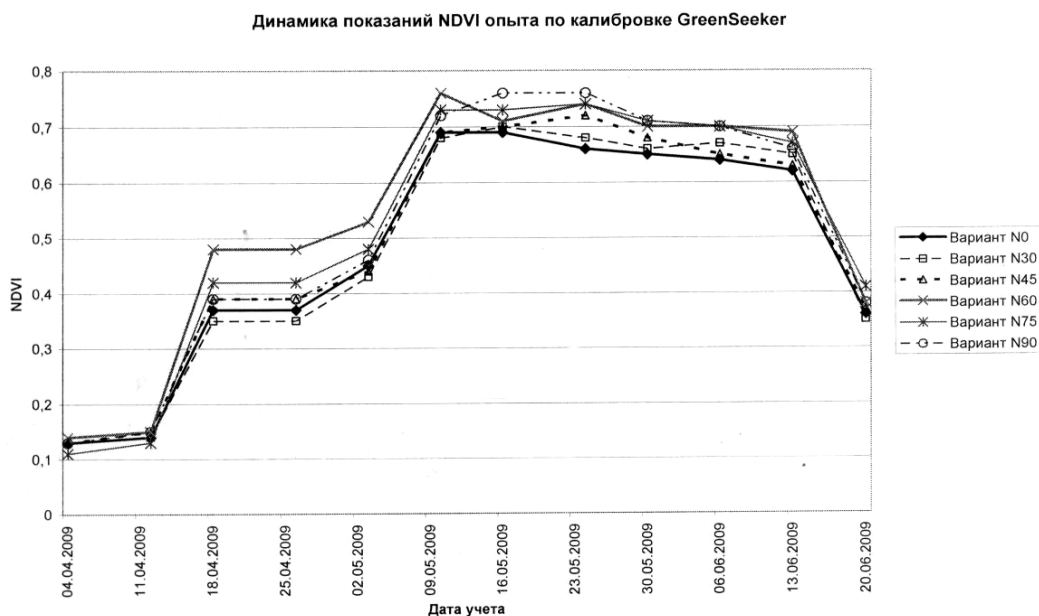


Figure 50. 5 NDVI measurements

384. Calculator was created according to the results of productivity for further validation of nitrogen fertilizers. Sites with enriched nitrogen were laid on three farmer's fields. Area of sites is 25 m². NDVI data measurement was carried out every day at the sites and on the farmer's field. NDVI data are given in the Table 50; schedule of NDVI registrations is shown in the Figure 51.

Table 50. NDVI data at the site enriched by nitrogen (en.N) and in the farm's field (f.f.)

Date of calculation	Site 1		Site 2		Site 3	
	en.N	f. f.	en.N	f. f.	en.N	f. f.
04.04.09	0.13	0.13	0.15	0.15	0.36	0.36
12.04.09	0.16	0.16	0.17	0.17	0.39	0.38
18.04.09	0.37	0.38	0.45	0.35	0.66	0.62
26.04.09	0.43	0.42	0.5	0.4	0.7	0.66
03.05.09	0.53	0.46	0.62	0.60	0.75	0.74
10.05.09	0.74	0.71	0.74	0.64	0.70	0.68
16.05.09	0.77	0.74	0.75	0.67	0.71	0.69
24.05.09	0.75	0.73	0.70	0.66	0.69	0.68
30.05.09	0.69	0.64	0.64	0.62	0.59	0.60
06.06.09	0.68	0.65	0.62	0.59	0.61	0.60
13.06.09	0.66	0.64	0.61	0.58	0.59	0.57
20.06.09	0.37	0.35	0.35	0.34	0.35	0.33

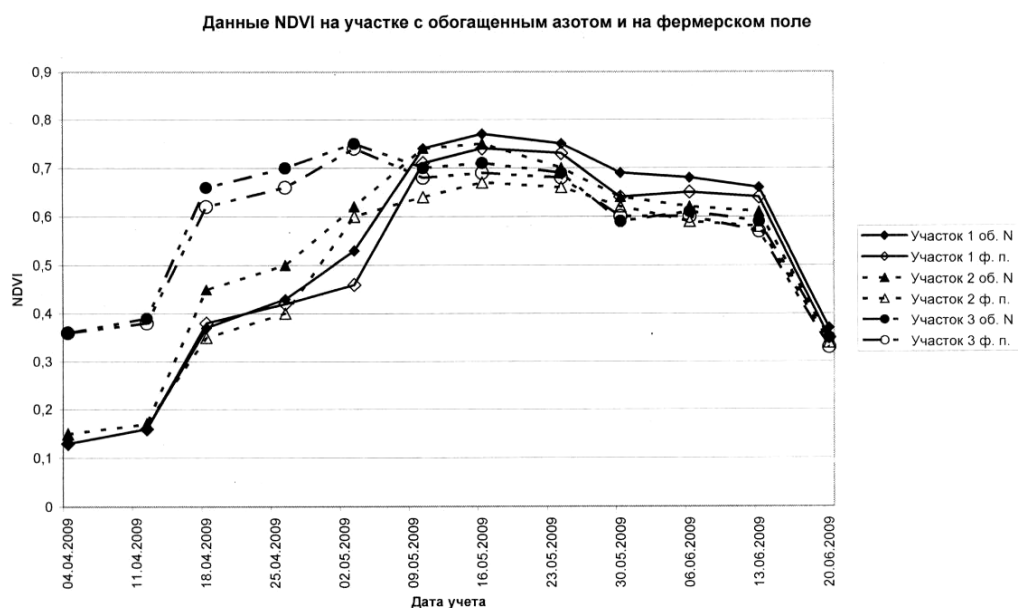


Figure 51. NDVI measurements

385. In the calculator obtained according to the calibration results of Greenseeker device in 2008 were calculated the needs in nitrogen fertilizers at farms' fields at the area of 25 m². Fertilizers were applied on 3 May 2009. Norms of fertilizers are shown in Table 51. Productivity of the fields, enriched with nitrogen and of the farm fields are shown in Table 17. As can be seen from the Table 52 with application of fertilizers norms calculated in the calculator, productivity increased for 80-140 kg.

Table 51. Needs in nitrogen fertilizers according to the calculator in calculation for 25 m²

Field	Norm of fertilizers, kg
Site 1	0.385
Site 2	0.124
Site 3	0.136

Table 52. Productivity on the farms' fields according to the validation, kgha-1

Site 1		Site 2		Site 3	
en. N	f. f.	en. N	f. f.	en. N	f. f.
2120	2040	2320	2280	2520	2400

3.11 Kyrgyzstan: Activity 7. Dissemination of results and developing mechanisms for upscaling and outscaling of the SLMR options

386. During the reporting period at the experiment site 2 field days were spent for demonstration the sowing of winter crops at zero till and 2 field days for demonstration of sowing maize by raised-bed planter.

387. In summer 2008 seminar was held with participation of the heads of the farms and the heads of Sokulukskiy district where laser land leveler and raised-bed planter for sowing stubble crops were demonstrated. Seminar's activity was shown in agricultural programs of the republican television and mass media.

388. 15 farmers learnt the work of leveler in the working order.

389. In 2008, 4 ha of maize and 2 ha of root crops in stubble planting were sown by the raised-bed planter.

390. In 2009 for introduction purposes 4 ha of maize and 5 ha of sunflower were sown by the raised-bed planter. Soil leveling was carried out for sugarbeet on the area of 2 ha.

Калькулятор по данным калировки озимой пшеницы по азотным удобрениям

STEP 1	STEP 2	STEP 3	STEP 4		STEP 5	STEP 6	STEP 7	STEP 8	STEP 9		STEP 10	
Enter Plot NDVI	Enter number of days from planting where GDD>0	Compute INSEY	Compute YPo	Determine Rindvi	Riyield	Compute YPn	YPmax determined by agronomist (YPn cannot exceed YPmax)	Determine Grain N uptake at YPo	Determine Grain N uptake at YPn		Determine fertilizer N requirement	
		= NDVI/ Days, GDD>0	YPo= 901.22*exp(229, 22* INSEY)	RI=NDVI (Nitrogen Rich Strip)/NDVI (farmer check)	Riyield(=Y) = 0,63 * Rindvi(=X) + 0,5256	YPn=YPo * RI	YPn(cap)<= 5000 kg/ha	GNUP_YPo = YPo in kg/ha * 0.0239	GNUP_YPn = YPn in kg/ha * 0.0239%		FNR = (GNUP_YPn - GNUP_YPo)/ 0.5043	
NDVI	GDD	INSEY	YPo, kg/ha	RI ndvi	RI yield	YPn, kg/ha	YPn(cap), kg/ha	GNUP_YPo	GNUP_YPn	N needed	FNR, kgN/ha	
1	0,3	102	0,002941	1769,5	1,7	1,6	2788,0	2788,0	42,3	66,6	24,3	121,7
2	0,33	102	0,003235	1892,9	1,5	1,5	2801,8	2801,8	45,2	67,0	21,7	108,6
3	0,4	102	0,003922	2215,4	1,3	1,3	2909,0	2909,0	52,9	69,5	16,6	82,9
4	0,35	102	0,003431	1979,9	1,4	1,4	2822,6	2822,6	47,3	67,5	20,1	100,7
5	0,36	102	0,003529	2024,9	1,4	1,4	2836,1	2836,1	48,4	67,8	19,4	96,9

NDVI Rich Strip =	0,5
NUE	20%

Average N 102,2

4 Tajik research report

4.1 Tajik research team

Table 53. Benchmark site 29 (Faizabad) and 30 (Vakhsh)

National Coordinator, Tajik Soil Science Research Institute (TSSRI) under Tajik Academy of Science	B. Kholov
Site Coordinator, Head of the Soil Erosion Department, TSSRI	R. Kabilov
Site Coordinator, Plant Scientist, Vakhsh branch of NGO (Scientific Production Association) “Zemledelie”	T. Gulov
Site Coordinator, Plant Scientist, Director of Vakhsh branch of NGO “Zemledelie”	M. Abdullaev
Senior Scientist, Irrigation Specialist, Vakhsh branch of NGO “Zemledelie”	O. Rakhmonov
Senior Scientist, Plant Specialist, Vakhsh branch of NGO “Zemledelie”	A. Yorov
Land Management Scientist, Head of Laboratory, Institute “Tochikzaminsoz”	A. Khakimova
Chemical Industry Worker, Institute “Tochikzaminsoz”	T. Sladkova
Principal Scientist, Head of Soil Fertility Enhancement and Assessment Department, TSSRI	Sh. Karaev
Senior Scientist, Head of Soil and Plant Nutrients Department, TSSRI	N. Ibragimov
Senior Scientist, Department of Land Amelioration, TSSRI	S. Hodjaev
Research Officer, Soil Scientist, TSSRI	Sh. Kabilova
Post-Graduate Student, Soil Scientist, TSSRI	D. Jumaev

4.2 Time schedule of research activities in Tajikistan 2007-2009

Table 54. Time schedule of research activities in Tajikistan 2007-2009

Tajikistan	Qr3	Qr4	Qr1	Qr2	Qr3	Qr4	Qr1	Qr2	Indicators	Outcomes
1. Effect of strip cropping on runoff and soil erosion on sloping land under in agri-horti production system	X	X	X	X	X	X	X	X	Annual Reports	Neighboring farmers practice the different technologies developed in the project to improve the quality of natural resources Institutions use the methodologies of comparative evaluation of SLM interventions
2. Study the impact of tillage, terrace configurations, snow catching for soil moisture conservation on yield of cereal crops and grapes and soil erosion on slopes		X	X	X	X	X	X	X	Technologies for crop production in sloping lands	
3. Rationale use of degraded sloping land for enhancing productivity in low and high rainfall regions		X	X	X	X	X	X	X	Technologies for soil-moisture conservation for terrace agriculture, gully plugs, and tree-crop combinations in agri-horti production systems	
4. Evaluate the efficiency of mechanical and vegetative measures in controlling gully erosion for rehabilitation of degraded sloping lands	X		X	X	X	X	X	X	Methodology for assessment of the agronomic and crop management interventions on growth and land quality	
5. Calibration and use of the Greenseeker for measuring crop development, comparing crop management practices and efficient nitrogen management		X	X	X	X	X	X	X		
6. Promoting communities-based nurseries for afforesting sloping lands	X		X	X	X	X	X	X		
7. Dissemination of results and developing mechanisms for upscaling and outscaling of the SLMR options		X	X	X	X	X	X	X	New cultivars for rice yield improvement	
8. Evaluate the performance of wheat, barley, rapeseed, cotton and halophytes grown on saline soils in Vakhsh		X	X	X	X	X	X	X	Methodology for assessing the agronomic management interventions on growth and land quality	
9. Study the impact of land-leveling and agronomic interventions on soil salinity and moisture distribution and crop performance using the EM probe and the Greenseeker				X	X	X	X	X	Technologies for rehabilitation of the saline soils	

4.3 Tajikistan: Activity 1. Effect of strip cropping on runoff and soil erosion on sloping land used for agri-horti production systems

4.3.1 Introduction

391. Tajikistan is one the most mountainous regions of Central Asia. Complex nature conditions of the country cause the occurrence of erosion processes in a high degree. That is why issues of studying erosion and fighting against it as well as increasing a fertility of eroded soils have a very important and practical meaning. In Tajikistan conditions where vertical soil zonality is sharply observed erosion processes are strongly developed in the zone of brown, typical, brown carbonate soils and dark sierozems. Meanwhile these soils are valuable for dry farming as the amount of precipitation here are quite high and the period of precipitation is comparatively long that provides the possibility to obtain high yields of many agricultural crops without artificial irrigation.

392. But strong relief ruggedness, frequent heave showers and weak soil resistance destructively influence on the water coming from the slopes and on the wind and are the reasons of strong soil erosion of Tajik Republic.

393. Land degradation due to water, wind and other anthropogenic factors constantly take place covering all big territories. That is why working out of erosion-preventive activities should be constantly upgraded with new approaches and decisions.

394. Sizes of soil erosion and damages due to erosion occurrence are so high that science designs are required for their prevention and their results should be introduced into production. For these reason development of mountain territories and fight against erosion is the most actual in Tajikistan. Positive decision of this issue is one of the most important an effective ways of fertility increasing of all agriculture crops.

395. Potential reserves for increasing the products production in the mountain are much more in comparison with obtained at present time. Development and usage of mountain territory and foothills zone has a great social-economic value particularly in solving the industrial program.

4.3.2 Objectives

- To work out soil protective techniques of crops cultivation at the eroded slope lands, which stipulate the improvement of agro chemical soil features, reduction of slope surface flow and washout, fertility increasing of eroded soils and increasing the industrial abilities of mountain brown carbonate soils.

396. The following tasks were determined in accordance with given purpose:

- To investigate the size of surface flow and washout of soils depending on the crop allocation at solid sowing and at line (strip) allocation.

- To study a water soil regime depending on line and solid allocation of the crops.
- To determine productive capacity of moderate washed brown carbonate soils at solid sowing and crops allocation in lines.
- To find out the changes in the content of nutrients (NPK) depending on agro technical activities.

4.3.3 Materials and Methods

397. Availability of considerable area of eroded soils in mountain agricultural regions of Central Tajikistan requires the usage of appropriate techniques for soil protection against erosion and for increasing the soil fertility. In the system of mountain agriculture a great role for fighting against erosion plays the agro technical methods which have their own features on the eroded soils, i.e. they should be erosion preventive and soil protective.

398. With a purpose of investigating the effect of line (strip) and solid planting of different crops on the surface flow and soil washout, increasing the fertility and productivity of moderate eroded brown carbonate soils experiment was carried out according to the following scheme:

- 1 Winter wheat (at the top of slope) hydrologic experimental plot;
alfalfa (down part of slope) at the hydrologic experimental plot;
- 2 Winter wheat (upper part of slope) + lentil - down part of slope
- 3 Lentil (upper part of slope) + winter wheat - down part of slope
- 4 Alfalfa (upper part of slope) + winter wheat - down part of slope
- 5 Black vapor solid
Winter wheat - solid
Alfalfa - solid

399. Experiment was carried out at the hydrological experimental plots located at the slope with inclination of 8-120 of south-eastern exposition. Size of hydrological experimental plot is 200 m², with 10 m width and 20 m length. There are two experiment replications.

400. Investigation of the influence of line (strip) and solid allocation of agricultural crops on the surface flow and soil washout was carried out at the experimental plots. Measurement of flow volume and washout accounting were carried out during the period of precipitation, most of which took place in March-May.

401. Water running along the chutes from the plots which were enclosed by concrete slabs was collected in the special tanks. After measuring the volume and through mixing, samples were taken from these tanks to 1.5 l plastic bottles for defining the amount of washed soil.

402. By necessary re-calculations volume of surface flow was defined in m³ ha⁻¹ and soil washout in kg ha⁻¹. In all the experiments under each crop dynamics of soil moisture was

determined every month from April to September at 1 m depth with half a meter interval in 10 cm, in the second half of meter in 25 cm.

403. Moisture was determined by thermostatic - gravimetric method.

4.3.3.1 Study site

404. Subjects of Research are moderate eroded mountain carbonate soils of Faizabad experimental site.

405. Climate of the experimental site can be explained by the complex of external influences which are defined by latitude and height above the sea level, atmospheric circulation and character of soil forming processes. Average annual amount of precipitation in Rasht valley, in particular in Faizabad district is made 866 mm, main part of which falls in winter-spring period and less amount falls in summer and autumn seasons (Table 1.3.1). Intensity of precipitation is made 0.5-3.25 mm/min. Big daily maximum of precipitation is observed in spring months (March, April, May) sometimes 100 mm and more falls per day. During cold half-year mostly rains and snows. As a result of snowing thick snow cover is formed on the soil surface and stays quite long in the foothills zone.

406. Strong mountain-valley winds dominate here and dry the soil. This creates an additional shortage of soil moisture. This district has moderate warm climate which enables the development of gardening, viticulture, potato growing and grain crops. Drought was observed in 2001 around the whole territory of the republic, amount of precipitation reduced for 30-45% (Table 1) together with a bit temperature increasing that led to the losses of grains and partially to the losses of dry fruit crops.

407. Faizabad site is located in the foothills zone of more dry-farming lands (rainfed) and has very poor plants due to the strong erosion processes (erosion drought). In spite of sufficient amount of precipitations site is located in the experimental conditions. This can be explained by active wind regime which dries the soil cover. Summer in this zone is dry and hot and winter is warm and wet. Two seasons are clearly singled out here: wet (winter-spring) and dry (summer-autumn). During the period of wet season, soils absorb moisture to the full field moisture capacity at 100 cm depth and more. Dry period lasts from April (May) till October (November) in some years (2007) till December. For this period of time whole meter and more thickness of soil becomes very dry till the maximum absorbability. By the middle of the summer moisture content in a metric layer reduces to the wilting coefficient. Thus water regime of brown carbonate soils refers to the not eroded type (Blagoveshenskiy and Kobilov, 1960; Blagoveshenskiy and Turdiev, 1961; Simavskiy, 1960).

408. Mountain brown carbonate soils develop under big grass semisavanna plants and xerophytes shrubs (almond, pistachio, hawthorn, rosary). Normal profile of mountain brown carbonate soils is differentiated at clearly displayed genetic horizons. Humus layer has the capacity of 30-35 cm with humus content of 3-5% (Table 56). After humus layer comes mother

rock with loess and loess-like loams. This soil subtype is spread at the down part of brown soil zone, at the heights from 700 (800) to 1400 (2000) m, and mainly refers to the low mountain forms of relief.

409. Site is located at the right bank of upland say (small canal) and at the south-eastern slope of adyrs with average surface inclination up to 15°. In the washed types (Table 56) content of humus and nitrogen sharply reduces. This is confirmed by the research and according to the soil erosion in Faizabad district where even at favorable relief soils with normal not damaged profiles are not available (Yakutilov, 1957).

410. High eroded soils contain less organic matter. In humus its content is made 1.48% in the layer of 20-60 cm – 0.79%, and on the soil surface carbonates content is made 17-21% (Table 56). Calcium carbonates on the upper layers of low eroded soils are not available. They are washed to the carbonate layers. Eroded degree is determined not only according to the chemical properties but also by physical. Moderate eroded brown carbonate soils differ from not eroded soils by more thick composition, more volume and specific weights, by less porosity (Table 55).

Table 55. Some hydro-physical soil properties of Faizabad experimental site

Name of soil	Depth,	Volume weight,	Specific weight,	Porosity,	PPB,	Moisture reserve m ³ ha ⁻¹
	cm	g cm ⁻³	g cm ⁻³	%	%	
Mountain Brown carbonate moderately eroded	10	1.09	2.51	56.6	20.3	221.3
	10-20	1.41	2.70	47.8	22.5	317.2
	20-30	1.41	2.74	48.5	22.2	313.0
	30-40	1.41	2.74	48.5	20.9	294.7
	40-50	1.45	2.74	47.1	20.0	290.0
	50-60	1.46	2.74	46.6	20.9	305.1
	60-70	1.48	2.77	46.6	21.1	312.3
	70-80	1.56	2.77	42.4	21.2	330.7
	80-90	1.61	2.77	41.9	21.4	344.5
	90-100	1.55	2.76	41.4	21.6	334.8
	0-100	1.44	2.72	46.74	21.21	3064.0

Table 56. Some chemical properties of eroded mountain brown carbonate soils of Fayzabad district.

Type of soil erosion	Depth, cm	Humus		Nitrogen		CacO ₃	PH water extract
		%	t ha ⁻¹	%	t ha ⁻¹		
Not eroded	0-15	3.58		0.23		1.07	7.82
	5-43	1.65		0.14		0.70	7.78
	43-77	1.19		0.06		32.05	8.25
	77-100	0.70		0.05		33.37	8.32
	0-20		84.83		5.39		
	0-50		126.84		10.13		
	0-100		189.54		13.73		
Low eroded	0-18	2.51		0.21		No	-
	18-32	2.30		0.19		No	-
	32-70	0.85		0.09		28.32	-
	70-120		64.71		5.40	31.24	-
	0-20		120.48		10.48		
	0-50						
Moderate eroded	0-22	1.48				17.36	8.05
	22-60	0.79				21.64	8.20
	60-100	0.60				32.39	8.10
	0-20		38.48				
	0-50		71.09				
High eroded	0-15	1.57		0.13		19.8	-
	15-50	0.69		0.07		31.28	-
	50-100					31.55	-
	0-20		35.1		2.99		
	0-50		62		5.71		

Table 57. Granulometric composition of eroded mountain brown carbonate soils, %

Type of soil erosion	Depth, cm	Losses due to the tillage	Size of fraction, mm							
			Sand			Dust			Alphitite	Silt
			>1	1-025	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.01	<0.001
1. Low eroded	0-18	1.20	0.0	0.36	0.26	44.92	11.58	15.02	53.26	26.66
	18-32	0.69	0.0	0.19	0.25	44.85	11.40	15.28	54.02	27.34
	32-70	28.58	0.0	1.96	0.127	31.68	11.06	10.31	37.61	16.24
	70-120	30.78	0.0	2.58	0.19	26.23	20.56	11.43	40.22	8.23
2. Moderate eroded	0-20	16.14	0.0	0.25	4.76	41.56	11.82	10.06	37.29	15.41
	20-60	18.94	0.0	0.11	2.44	43.17	8.29	13.19	35.34	13.86
	60-100	18.16	0.0	0.09	6.02	39.33	11.14	7.20	36.40	18.06

Table 58. Structural (numerator) and aggregate (denominator) composition of mountain brown carbonate soils of different washing degree.

Type of soil erosion and their location	Depth, cm	Cropland	Fraction, mm						
			>3	3-2	2-1	1-0.5	0.5-0.25	<0.25	0.25
Low eroded,	0-18	Arable land	70.5	4.9	9.6	3.0	2.0	10	90.0
Faizabad			1.2	1.4	1.2	24.9	2.7	68.6	31.4
	18-34		83.8	2.9	5.6	1.8	1.5	4.4	95.6
			1.0	6.6	5.9	18.5	2.9	65.1	34.9
	34-62		70.2	4.5	9.5	4.1	3.6	8.1	91.9

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			0.7	2.9	2.7	21.3	2.6	69.9	30.2
	62-100		68.0	5.8	9.4	2.6	2.0	12.2	87.2
			7.5	3.7	2.3	25.0	3.7	57.8	42.2
	100-150		67.8	4.4	10.4	2.6	2.4	12.4	87.6
			2.4	2.4	12.2	3.0	3.3	76.7	23.3
High eroded,	0-20		61.5	3.5	15.5	7.0	7.5	5.0	95.0
Faizabad			14.3	3.0	2.8	27.0	2.3	50.6	49.4
	20-36		78.4	4.0	7.0	3.5	3.9	3.2	96.8
			23.7	5.6	3.6	14.4	1.4	51.3	48.7
	36-80		65.2	8.5	5.3	5.0	4.6	11.4	88.6
			19.1	4.1	3.5	11.9	1.9	50.5	40.5
	80-110		59.6	6.0	12.4	5.2	5.4	11.4	88.6
			12.9	2.4	3.0	6.8	2.6	72.3	27.7
	110-150		46.8	7.4	14.4	5.2	4.6	20.6	79.4
			4.8	3.0	5.2	15.8	3.0	68.2	31.8

411. Moderate eroded mountain brown carbonate soils according to their granulometric composition refer to the big sandy heave loams. Silt and apatite content is considerably less in the upper layers of these soils than in the not eroded soils. As a result of erosion processes the smallest particles of soils are washed out therefore granulometric composition of eroded soils becomes harder (Table 57). Table 58 contains the data of structural and aggregate composition of mountain brown carbonate soils at different erosion degree. It should be pointed out that low eroded mountain brown carbonate soils which are used in agriculture (cropland) are characterized by small content of water-stable aggregates, more than 0.25 mm is made 31.4% in the plough-layer and 34.9 in sub-plough-layer.

412. The main weight of water-stable aggregate in the plough-layer is represented by the aggregates of 1.0-0.5 mm size, about 25%, in the sub-plough layer together with aggregates 1.0-0.5 mm an important place takes bigger aggregates (1-3 mm).

413. In carbonate layer (62-100 cm) of low-eroded mountain brown carbonate soils amount of water-stable aggregates more than 0.25 mm is considerably more (42.2%), than in the upper humus layer. The reason is that in carbonate layer as it was mentioned above calcium carbonate is observed in a big amount which being in the content of aggregates stipulates the formation of water-stable aggregates. Besides that in this layer frequently can be met carbonate "*juravchiki*" which increase the total amount of water-stable aggregates of more than 0.25 mm. Mother rock loessial sediments (100-150 cm) of low-eroded mountain brown soil are characterized by even less content of water-stable aggregates which is bigger than 0.25 mm (23,3%).

414. Moderate eroded mountain carbonate soils are met in general at the slopes of eastern, western and southern exposition with inclination of 5-10°. Humus layer is fully washed out from them. Strongly boiled part of transitional layer with poor humus content comes out to the day surface of moderate eroded soils. On the eroded soils requirements for soils protection against erosion should take into account the issues of farms specialization and allocation of croplands.

415. According to M.R. Yakutilov, M.N. Zaslavskiy, Kh.M. Akhmadov and others one-year crops should be cultivated at the slope of not more than 10-12°. At more steep slopes as a rule soils are much eroded that is why production of one-year crops do not cover the costs spent for material facilities and labor. It is better to use them for gardens and vineyard with terrace agriculture.

416. Crop rotation at the slope not only should create conditions for high yield but also prevent the development of erosion processes and provide productive usage of eroded soils.

4.3.4 Results and discussion

417. In 2008 investigation of various agrocoenosis and agro techniques influence on the productive capacity of eroded soils was carried out in Faizabad base station in rainfed conditions in the zone of moderate eroded brown carbonate soils.

418. One of the perspective techniques for soil protection against erosion is a crop planting in line at the slope lands. At line planting grains should be sown across the slope and should be alternated with one-year plowed and perennial herbaceous plants.

419. Such allocation of crops enables to determine soil protective role of each planting crop. Results of the Research show that in extremely dry year of 2008 in March-May surface flow and soil washout almost were not observed. It is very important to carry out water-protective activities taking into account that in such extremely dry years in rainfed conditions where moisture is the main factor which limits obtaining stable yields.

420. Observation results over the soil moisture show that at the experimental plots at line planting of different agrocoenosis moisture content in the upper half of meter (in May) was negative, only in the second half of meter was positive. In July under all experimental variations in metric layer effective reserves of moisture were totally negative.

421. Research results show that in years with small amount of precipitation is not reasonable to plant spring crops because all the spring crops dried out, only winter crops gave the yield of grains and leguminous crops but their rates were too low – 2.4 centner ha⁻¹

422. Crops productivity at rainfed soils depends on climatic conditions and agro technical methods of their cultivation. At the experimental plots in drier years yield of grain and legumes sometimes fully dries out or very low and productivity of perennial grasses (alfalfa, esparzet) also reduces in two times and is made 20-25 centner ha⁻¹ while in the years of abundant precipitation productivity of biennial alfalfa and esparzet reaches to 70 and more centner ha⁻¹.

423. Besides line planting at the experimental plots experiment was carried out at the area of one hectare in two sites with different inclination of soil surface. At the first site with inclination of 16-18° line planting was carried out according to the following scheme: lentil + spring wheat + alfalfa. At the second site with inclination of 6-8° line planting was carried out according to the following scheme: spring wheat + lentil + alfalfa. Spring crops planting was carried out at the both sites in one day at the beginning of March 2008. Additional fertilizing with nitrogen in calculation of 60 kg of reactant was carried out on 15-20 April for all crops. At the first site with inclination of 16-18° all the crops fully dried out. At the second site with inclination of 6-8° agriculture crops' yield was obtained. First site is located at the windy part of slope for this reason at small amount of precipitation moisture quickly evaporated due to strong wind and big illumination of the territory.

424. The second site is located at the down part in the gorge between two hills that is why it is protected from wind and moisture stayed in considerable amount especially in the second half of meter. The facts mentioned above fully confirm the data of effective moisture reserves while comparing upper and down parts. If compare effective moisture reserves under spring wheat in upper and down part of the site then moisture amount in the second half of meter (15 June) of the down part was in two times more then at the upper part. Soil drying was less intensive at the down part of the site then at the upper one. Hereupon if at the upper part of the site all the crops dried then in down part of the site yield was not so bad.

425. In 2009 amount of precipitation was very high in comparison with 2008, spring was relatively cold and rainy. Crops which are cultivated at the slopes have different soil-protective properties depending in their biological features, projective soil cover in spring when precipitations are more intensive. Hereupon degradation and drift of upper soil layer by surface flow take place in different ways under the various crops.

426. It was determined by a number of Research that fast formation of plant covering with leaves and green mass in spring protects the soils from surface flow and washout due to the rain shower. Research results show that regularity of surface flow and soil washout remains the same as in previous years.

427. The highest rate of surface flow and soil washout was observed at the variation of black vapor and has been made $557 \text{ m}^3 \text{ ha}^{-1}$ and $20 \text{ thous. kg ha}^{-1}$, while in other variations at solid planting surface flow under winter wheat has been made $422 \text{ m}^3 \text{ ha}^{-1}$ and 7934 kg ha^{-1} i.e. for 250% less than at black vapor. And at solid planting of alfalfa surface flow was $296 \text{ m}^3 \text{ ha}^{-1}$ and 3565 kg ha^{-1} , i.e. for 143% of flow and 220% of soil washout less than at solid winter wheat planting. In black vapor during precipitations in spring soil surface is not protected from direct rain drops that cause fast soil spreading. Soil structure destroys as a result of which pores are silted and hard crust is formed, soil permeability strongly reduces that leads to the big surface flow and soil washout.

428. At line planting surface flow has been made from 130 to 112%, and soil washout from 182 to 108% less in comparison with winter wheat solid planting (Table 59).

429. Great interest represents an observation over water regime of soils under various agrocenosis. In order to obtain high yield the main issue is to collect and maintain moisture in soil. It is especially important in conditions of rainfed agriculture.

430. According to academician V.R. Williams (1936): «The main law of soil fertility is: soil should constantly supply the plant with maximum quantity of water and nutrient». Natural conditions in deserts and semi deserts with continental climate and dry periods make a very strong influence on vital functions of the plants.

431. Year 2008 was very hot and dry; precipitation was at a rate of 50% from average annual. Investigation results of moisture regime in the soils show that in all experimental variations effective moisture reserve in metric layer was positive and very high.

432. According to the results total rate of moisture with various agrocenosis is not the same. In May-June at solid planting the highest moisture rate was observed at solid planting of winter wheat and alfalfa and has been made more than thousand $m^3 ha^{-1}$ (Table 60). At line planting total rate of moisture is less and has been made 600-800 $m^3 ha^{-1}$ (Table 60).

433. Moisture rate is increasing due to rainfalls stop and warm days start as well as intense development of plants. According to the moisture content in metric soil layer at line planting big difference is not observed in all the variations. Soil in metric layer is fully wet, especially big moisture content was observed in May. This is related to the abundant rainfall at the second half of April and in May.

434. Besides line crop planting at the experimental plots industrial experiment was carried out at the area of one hectare in two sites. At the first site with inclination of 16-18° line planting was carried out according to the following scheme: winter wheat + lentil + alfalfa. At the second site with inclination of 6-8° line planting was carried out according to the following scheme: lentil + winter wheat + alfalfa. Research results of soil moisture under various agrocenosis show that content of effective moisture reserves in both sites is very nice.

435. It should be pointed out that at the second site content of effective moisture reserve in a metric soil layer in May under alfalfa is 39%, under lentil for 19% was higher than in the first experiment (Table 61). In June amount of effective moisture reserve under lentil has been made 29, under winter wheat - 61, and under alfalfa - 19% more than at the second site (Table 61).

436. All this confirms the results of the year 2008 that soil siccation at the second site took place less intensive than at the first site. Wind regime of Faizabad negatively influence on the moisture preservation in the soil, and dries it very much.

437. Crops productivity depends on the amount of rainfalls and nutrient regime of the soils. If one of these components is not enough then good yield would not be obtained.

438. Research results show that if rainfalls in May fall irregular during month not less than 80-100 mm then in spite of abundant rainfalls during winter period good yield of winter and spring wheat will not be obtained.

439. In this relation year 2009 was very nice, crops had nutrients and water. As a result very good yield of winter wheat was obtained at the down part of slope up to 23-26 centner ha^{-1} , while in the upper part of slope productivity of all crops was less than at the down part of slope and has been made 13.8-18.0 centner ha^{-1} (Table 62).

440. It is obvious that as a result of surface flow and soil washout water and nutrient elements wash to the down part of slope. That is why crops at the down part of the slope have additional moisture and nutrients. Efficiency of line planting is that surface flow and soil washout do not take nutrient elements and water out of the territory of line planting. In industrial experiment regularity of crops productivity is the same as at the experimental plots with line planting.

4.3.5 Conclusions

441. In rainfed conditions at slope lands, solid planting of winter and spring crops leads to the considerable surface flow ($300-400 \text{ m}^3 \text{ ha}^{-1}$) and soil cover washout ($5-9 \text{ t ha}^{-1}$), that cause a strong water erosion and land degradation.

442. One of the measures to prevent it is to introduce allocation of crops in line with introducing 30-40% of area under legumes-cereals which reduce the surface flow for 20-25% and soil washout for 40-50%, and improve hydro physical properties and increase the soil fertility for the account of biologization of soil processes.

Table 59. Surface flow $\text{m}^3 \text{ha}^{-1}$ (numerator) and soil washout kg ha^{-1} (denominator) at the experimental plots at line and solid crops planting for 2009

Experimental variation	5.04	6.04	13.4	14.04	8.04	21.04	7.04	28.04	4.05	5.05	7.05	8.05	9.05	14.05
1. Black vapor	<u>22.5</u>	<u>42.5</u>	<u>30.0</u>	<u>52.5</u>	<u>30.0</u>	<u>60.0</u>	<u>25.0</u>	<u>35.0</u>	<u>25.0</u>	<u>45.0</u>	<u>25.0</u>	<u>20.0</u>	<u>40.0</u>	<u>20.0</u>
	108.9	871.2	420.0	2126.2	900.0	5550.0	637.5	1225.0	812.5	1575.0	375.0	500.0	2320.0	400.0
2. Winter wheat, B Alfalfa, H	<u>2.5</u>	<u>35.0</u>	<u>2.0</u>	<u>40.0</u>	<u>20.0</u>	<u>45.0</u>	<u>17.5</u>	<u>10.0</u>	<u>15.0</u>	<u>25.0</u>	<u>15.0</u>	<u>5.0</u>	<u>30.0</u>	<u>7.5</u>
	Not	612.5	Not	1400.0	230.0	1057.0	148.7	105.0	375.0	750.0	79.5	3.5	339.0	26.2
3. Winter wheat, B Lentil, H	<u>1.50</u>	<u>39.0</u>	<u>4.0</u>	<u>30.0</u>	<u>25.0</u>	<u>37.5</u>	<u>24.0</u>	<u>25.0</u>	<u>25.0</u>	<u>25.0</u>	<u>25.0</u>	<u>15.0</u>	<u>32.5</u>	<u>10.0</u>
	Not	702.0	Not	1400.0	420.0	1312.5	492.0	350.0	262.5	575.0	18.7	217.5	763.7	53.0
4. Lentil, B Winter wheat, H	<u>1.75</u>	<u>30.0</u>	<u>9.7</u>	<u>32.5</u>	<u>28.0</u>	<u>38.0</u>	<u>25.0</u>	<u>24.5</u>	<u>10.0</u>	<u>25.0</u>	<u>25.0</u>	<u>15.5</u>	<u>30.0</u>	<u>15.0</u>
	Not	456.0	Not	536.2	490.0	1527.5	397.5	310.0	100.0	312.5	22.5	262.5	405.0	142.5
5. Alfalfa, B Winter wheat, H	<u>0.5</u>	<u>32.5</u>	<u>1.5</u>	<u>25.0</u>	<u>24.0</u>	<u>34.0</u>	<u>24.5</u>	<u>19.0</u>	<u>25.0</u>	<u>25.0</u>	<u>10.0</u>	<u>10.0</u>	<u>35.0</u>	<u>10.5</u>
	Not	471.0	Not	362.0	252.0	1118.6	245.0	182.4	300.0	300.0	5.3	4.0	525.0	5.2
6. Winter wheat, solid	<u>15.0</u>	<u>32.0</u>	<u>21.5</u>	<u>40.0</u>	<u>27.5</u>	<u>47.5</u>	<u>19.0</u>	<u>25.0</u>	<u>22.5</u>	<u>32.5</u>	<u>20.0</u>	<u>14.0</u>	<u>25.0</u>	<u>15.0</u>
	37.5	598.0	Not	1008.0	495.0	2137.5	285.0	512.5	461.2	1040.0	5.6	168.0	425.0	195.0
7. Alfalfa, solid	<u>10.0</u>	<u>24.0</u>	<u>9.5</u>	<u>22.5</u>	<u>23.0</u>	<u>30.0</u>	<u>14.0</u>	<u>20.0</u>	<u>15.0</u>	<u>20.0</u>	<u>15.0</u>	<u>10.0</u>	<u>22.5</u>	<u>9.0</u>
	10.4	235.2	Not	292.5	213.9	600.0	728.0	210.0	180.0	280.0	40.5	75.0	236.2	56.7

Table 60. Effective moisture reserve, m³ ha⁻¹ at line and solid crops planting for 2009

Experimental variations	Slopes	19.04.2009			16.05.2009			14.06.2009		
		0-50	50-100	0-100	0-50	50-100	0-100	0-50	50-100	0-100
1. Winter wheat,										
alfalfa	Upper	614	720	1334	796	1084	1880	692	846	1538
	Down	614	916	1530	809	1070	1879	601	895	1496
2. Winter wheat,										
lentil	Upper	711	552	1263	848	0	1757	549	580	1129
	Down	588	762	1350	750	1056	1806	321	601	922
3. Lentil,	Upper	705	755	1460	796	1035	1831	373	727	1100
winter wheat	Down	854	811	1665	731	979	1710	510	566	1076
4. Alfalfa, winter wheat	Upper	Not defined			802	1050	1852	451	748	1199
	Down	Not defined			919	1050	1969	445	412	857
5. Black vapor	Solid	510	713	1223	796	1084	1880	685	804	1489
6. Winter wheat	Solid	Not defined			679	1000	1679	308	356	664
7. Alfalfa	Solid	Not defined			763	965	1728	334	342	676

Table 61. Effective moisture reserve under the line planting of crops in industrial experiment at the slope with 16-18° inclination, m³ ha⁻¹

Experimental variation	20.04.2009			16.05.2009			15.06.2009		
	0-50	50-100	0-100	0-50	50-100	0-100	0-50	50-100	0-100
Lentil top of slope	776	979	1755	654	923	1577	460	811	1271
Winter wheat middle of slope	585	720	1305	838	969	1807	485	629	1114
Alfalfa down part of slope	703	920	1623	676	910	1586	664	857	1521
Experiment №2 at the slope of 6-8° inclination									

	23.0.4.09			17.05.2009			15.06.2009		
Winter wheat top of slope	877	1252	2129	755	1119	1874	738	889	1627
Lentil middle part of slope	915	1242	2157	883	951	1834	784	1007	1791
Alfalfa down part of slope	945	1186	2131	1065	1175	2240	836	976	1812

Table 62. Crops productivity at the experimental plots for 2009.

Experimental variation	Slope	Height of plant, cm	Replication			Average yield, g/m ²	Yield, centner ha ⁻¹
			1	2	3		
1. Winter wheat, alfalfa	Top	95	170.0	180.0	190.0	180.0	18.0
	Down	80	710.0	709.0	690.0	700.0	70.0
2. Winter wheat, lentil	Top	105	130.0	145.0	140.0	138.0	13.8
	Down	40	65.0	90.0	85.0	80.0	8.0
3. Lentil, winter wheat	Top	38	63	75	90	76.0	7.6
	Down	98	245	257	180	227.3	22.7
4. Lentil, winter wheat	Top	53	300	350	290	31.30	31.3
	Down	98	250.0	270.0	260.0	260.0	26.0
5. Winter wheat, solid		93	205.0	200.0	180.0	195.0	19.5
6. Alfalfa, solid		75	680.0	900	700.0	760.0	76.0
Industrial experiment №1 Lentil, winter wheat, alfalfa	Top	35	100.0	95.0	90.0	95.0	9.5
	Middle	90	150.0	125.0	130.0	135.0	13.5
	Down	90	650.0	500.0	750.0	633.0	63.3
Experiment №2 winter wheat, lentil, alfalfa	Top	110	150.0	165.0	170.0	161.6	16.2
	Middle	38	108.0	95.0	100.0	101.0	10.1
	Down	95	650.0	600.0	750.0	666.6	66.7

443. Development of slope lands with cultivating different agriculture plants considerably changes the character and quantity of biomass in the soil. Effect of general regulations of plant formations on the soil formation process were determined by V.R. Williams (1949). According to his theory of combining ligneous, meadow, steppe and desert plants with mushrooms, ray fungus, aerobic bacterium in different zones forms the plant formation on which depends the formation of soil type.

444. Issue of increasing the soil fertility requires the working out of new methods for elements regulating for soil fertility that can be achieved by selection and alternation of crops, ways of soil tillage, taking erosion-protective measures. In the process of slope lands development, decomposition of plants residue takes place as well as strong mineralization of total humus and nitrogen. Problem of increasing the soil fertility requires the working out in industrial conditions the new methods of regulating the elements for soil fertility, in particular determination of changing the parameters of biological properties under the influence of anthropogenic impact of soil improvement. As a result of intense erosion processes soil depletes humus and other nutritious elements.

445. The most favorable conditions for collecting humus are created at optimal soil biogeny, a number of new formations of humic acid a bit prevail over the rate of decomposition (Akramov Yu., Rodyakova P.F., 1980). Such soils are mountain brown soils. Biogeny strengthens coming closer to sierozems and as a result of humus collection reduces.

446. Research results of humus content show that long-term cultivation of grains does not stipulate humus collection. The biggest change in humus content takes place under the black vapor. For 8 years almost all the plowing layer washed out from the vapor field, humus content reduced more than in 3 times (Table 63).

447. At alfalfa planting humus and nitrogen content increases, at the same time humus content is observed in sub-plough layers of the soils.

448. A great role in fertility reclamation and winter wheat productivity increasing at the eroded soils plays fertilizers. Erosion-preventive value of mineral fertilizers becomes apparent through their favorable influence on the vegetation condition, notably on increasing of aboveground and underground plants' biomass.

Table 63. Changing of humus content in line and solid crop planting at the experimental plots

Experimental variations		25.05.01			4.04.08		
		Depth, cm	Humus, %	Humus reserve, t ha ⁻¹	Depth, cm	Humus, %	Humus reserve, t ha ⁻¹
1.	Winter wheat, top of slope	0-30	1.12	43.7	0-30	0.84	32.8
		30-50	0.55	14.3	30-50	0.70	18.2
		0-50	0.89	58.0	0-50	0.78	51.0
	Alfalfa, down part of slope				0-30	1.31	51.5
					30-50	0.80	20.8
					0-50	1.11	72.3
2.	Winter wheat, top of slope	0-30	1.41	55.0	0-30	0.87	33.9
		30-50	1.29	33.5	30-50	0.50	13.0
		0-50	1.36	88.5	0-50	0.72	46.9
	Lentil, down part of slope	0-30	0.99	38.6	0-30	0.94	36.7
		30-50	0.73	19.0	30-50	0.69	17.9
		0-50	0.88	57.6	0-50	0.84	54.6
3.	Lentil, top of slope	Not defined	Not defined	Not defined	0-30	0.89	34.7
					30-50	0.70	18.2
					0-50	0.81	52.9
	Winter wheat, down part of slope	Not defined	Not defined	Not defined	0-30	0.94	36.7
					30-50	0.84	21.8
					0-50	0.90	58.5
4.	Alfalfa, top of slope	0-30	1.59	62.0	0-30	1.58	61.6
		30-50	1.08	26.8	30-50	1.30	33.8
		0-50	1.37	88.8	0-50	1.47	95.4
	Winter wheat, down part of slope						
1.	Black vapor, solid	0-30	3.14	122.4	0-3-	0.82	32.0
		30-50	2.16	56.2	30-50	0.34	19.2
		0-50	2.75	178.6	0-50	0.79	51.2
2.	Alfalfa, solid	0-30	1.59	62.0	0-30	1.85	72.1
		30-50	1.10	28.6	30-50	1.08	28.1
		0-50	1.39	90.6	0-50	1.54	100.2
3.	Winter wheat, solid	0-30	1.37	53.4	0-30	1.03	40.2
		30-50	0.94	24.4	30-50	0.62	16.1
		0-50	1.20	77.8	0-50	0.87	56.3



Figure 52. Line planting of agricultural crops at the slope lands with 89-120 inclination. Winter wheat



Figure 53. Line planting at the slope lands with 8-12° inclination. Alfalfa



Figure 54. Solid black vapor.

4.4 Tajikistan: Activity 2. Study the impact of tillage, terrace configurations, and snow catching on soil and moisture conservation and yield of grapes in sloping landscapes

4.4.1 Introduction

449. More attention is paid to the investigation of erosion processes as erosion having destroyed the soils undermines the possibility of increasing the production of agricultural products. In the scale soil erosion and damages that it causes are so high that considerable changes are required in the economical activity of human being and nature management in order to overcome it.

450. In Tajikistan conditions where vertical soil zonality is sharply observed erosion processes are strongly developed in the zone of brown carbonate soils and dark sierozems. Meanwhile these soils are valuable for dry farming as the amount of precipitation here are quite high and the period of precipitation is comparatively long that provides the possibility to obtain high yields of many agricultural crops without artificial irrigation

451. But strong relief ruggedness, frequent heavy showers, strong soil degradation, small percentage of forest lands destructively influence on the water coming from the slopes and are the reasons of strong soil erosion of Tajik Republic.

452. Soil-protective measures should be taken in order to reduce and prevent the damages caused by erosion. Application of fertilizers, crops' allocation and rotation are very important in this issue. Crop rotations at the slopes should not only create conditions for obtaining high yields but also prevent the development of erosion processes and provide productive usage of eroded soils.

453. In this relation, selection and placement of the crops should be carried out taking into account allocation of arable lands along the slopes, washing degree and potential danger from erosion..

454. The main purpose of implemented Research is to work out more effective erosion-protective agro technical and other techniques which stipulate fertility increasing of eroded soils at the slopes by cultivating orchard and other agricultural crops, maintain soil fertility and protect from further degradation.

4.4.2 Objectives

455. Purpose of work is to explain theoretically and to work out various methods of crop cultivation at the eroded terraced slope lands, which can improve the agro technical, physical properties of the soils and increase the fertility of eroded soils and productive capacity of mountain brown carbonate soils.

456. The following tasks were determined in accordance with given purpose:

- To investigate a water regime depending in different agro technical activities.

- To find out the changes in content of humus and nutrient elements (NPK) depending on agro technical activities.
- To determine the effect of various agro technical activities on the soil productivity.

4.4.3 Materials and methods

457. Terraces are the radical agro technical techniques for regulating the surface flow and soil washout. They help to prevent not only erosion but drought as well. However having created a favourable water regime at terracing, soils have a shortage of nutrient elements, especially of nitrogen and humus matters. In particular at constructing terraces by taking-out and pouring method because all the fertile soil is cut. That is why at the terraced site it is necessary to rehabilitate soil fertility at the beds of terraces.

458. Experiment was carried out at the vineyard (fruit bearing) terrace. In this experiment moisture supply measures are investigated that influence on water regime, fertility and productive capacity of the soils according to the following scheme:

1	Plowing (black vapor) control.
2	Mulching of terraces by using straw (hay) of natural vegetation.
3	Mulching of terraces by using the cutting of vineyards.
4	Technology of snow retention at the terraces as agro technique for moisture preservation as the taken-out terraces and vineyards are the factor of snow retention and moisture collection.

459. In all the variations moisture dynamics of the soils is determined monthly to one meter depth, in July to two meter depth.

460. Experiment is in three replications. Experiment was carried out at three terraces, each of them were replication. Size of plot is 140 m² (at 3.5 m width and 40 m length). 20-30 shrubs of vine were planted in each replication.

461. Moisture preserving techniques - mulching was used in terraced moderate washed brown carbonate soil. Straw (hay) with 10 cm thickness and vine cuttings of 10 cm layer were used as mulch. Soil samples were taken from plowing (0-30 cm) and sub-plowing (30-50 cm) layers for defining content of humus and mobile forms of NPK.

462. In all soils samples determination was carried out of nitrate nitrogen according to Shafferstein, Lipkind, Save (1962); ammonium nitrogen - by Nessler's reagent; mobile phosphorous according to Machigin, Protasov; humus according to Tyurin, mobile phosphorous and exchangeable calcium in 1% of carbon-ammonium extract by the method of Machigin and Protasov.

4.4.3.1 Study site

463. Mountain brown carbonate soils develop under the big size grass semisavanna plants and xerophytes shrubs (almond, pistachio, hawthorn, rosary).

464. Normal profile of mountain brown carbonate soils is differentiated to clearly displayed genetic horizons. Humus layer has the capacity of 30-35 cm with humus content of 3-5%. After humus layer comes carbonate layer where carbonates appears as a mold and loess dolls. Their quantity reaches up to 24.0-27.0%. After carbonate layer comes mother rock represented by loess and loess-line loams.

465. Moderate washed soils contain less humus. In humus layer - 1.82% and in the layer of 20-39 cm-1.38%, and carbonates on the surface have 15-18% (Table 64).

Table 64. Some chemical properties of soils at experiment plots

Name of soils and croplands	Depth, cm	Humus, %	Gross nitrogen, %	CaCO ₃ , %	PPB, %
Mountain brown moderate eroded, arable land	0-20	1.82	0.210	15.2	22.5
	20-39	1.38	0.084	18.0	22.2
	39-60	0.88	0.090	25.0	20.9
	60-80	0.71	-	27.6	20.0
	80-100	0.71	-	25.2	21.1
	100-140	0.71	-	24.8	21.6

466. Erosion degree can be determined not only according to the chemical properties, but according to the physical as moderate eroded brown carbonate soils differs from not eroded soils by more dense composition, by increasing of volume and specific weights and by porosity reduction (Table 65)

Table 65. Some hydro-physical properties of soils at experimental plots

Name of soil	Depth, cm	Volume weight, g cm ⁻³	Specific weight, g cm ⁻³	Porosity, %	PPB, %	Moisture reserve, m ³ ha ⁻¹
Mountain brown moderate eroded	0-10	1.09	2.51	56.6	20.3	221.3
	10-20	1.41	2.70	47.8	22.5	317.2
	20-30	1.41	2.74	48.5	22.2	313.2
	30-40	1.41	2.74	48.5	20.9	294.7
	40-50	1.45	2.74	47.1	20.0	290.0
	50-60	1.46	2.74	46.6	20.9	305.1
	60-70	1.48	2.77	46.6	21.1	312.3
	70-80	1.56	2.77	47.2	21.2	330.7
	80-90	1.61	2.77	41.9	21.4	344.5
	90-100	1.55	2.76	41.4	21.6	334.8
						306.4

467. Moderate brown carbonate soils according to their mechanical texture refer to big dusty heavy loams. At the top layers of these soils content of silt and alplitite is considerable less than in not eroded soils. The reason is that as a result of erosion processes the smallest soil particles are washed out and therefore mechanical texture of eroded soils becomes poor (Table 66).

Table 66. Mechanical composition of not eroded, moderate eroded mountain brown carbonate soils, %

Type of erosion	Depth cm	Losses due to tillage %	Size of fraction, mm							Alphitite
			sand			dust				
			> 1	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	< 0.001	
Not eroded soil	0-15	1.02	0.00	0.00	0.00	44.55	14.25	16.22	23.96	54.4
	15-48	0.58	0.00	0.00	0.00	44.20	15.00	15.00	25.22	55.2
	48-77	31.95	0.00	0.00	0.00	30.30	11.62	10.08	16.05	37.7
	77-100	32.74	0.00	0.00	0.00	30.27	13.45	10.09	13.45	36.9
Moderate eroded	0-20	16.14	0.00	0.25	4.76	41.56	11.82	10.06	15.41	37.21
	20-60	18.94	0.00	0.11	2.64	43.17	8.29	13.19	13.86	35.30
	60-100	18.16	0.00	0.09	6.02	39.33	11.14	7.20	18.06	36.40

4.4.4 Results and discussion

468. One of the most effective methods of fighting against soil erosion at the lip slopes is terrace agriculture by using of which slopes can be used as for one-year so for perennial orchard crops. From the position of using resources of soil waters, mulching is a very effective method for reducing the unproductive water expulsion by soils and for increasing the water supply for plants.

469. Research results show that effective moisture reserve under mulches positively remains in one meter layer till July, only in control variation (black vapor) it was very negative (Table 2.5.1). Thus, in the terraces various mulching techniques stipulated considerable accumulation of the rainfalls in the soils that made an influence on their effective usage in comparison with slope lands without terracing.

470. According to the data of Table 2.5.2 vineyard yield at the terraced slopes depends on the effect of used variations. Plowing of terraces gives less vineyard yield and mulching of vine cuttings – 45.9 centner ha⁻¹. Higher vineyard yield was observed in the variation where hay was used as a mulch, and where vineyard yield has been made 56.1 kg ha⁻¹.

471. Research results show that vineyard productivity at the poured part of terrace varied from 7 to 35% and is made less than at the taken-out part of terrace. Most probable it is connected with more illumination and heating of the poured part of terrace as a result of which soil becomes very dry at the taken-out parts of terrace.

472. It should be pointed out that vineyard productivity mainly depends on the reserve of moisture and nutrients. In such extremely dry years (2008) obtaining such yield at the rainfed is quite satisfactory.

473. In the terraces different techniques of mulching stipulate considerable accumulation of rainfalls in the soils that makes an influence on their effective consumption in comparison with control (black vapor). It was determined by the investigations that terracing of slope lands introduce essential changes as to hydrological regime of slopes so to the intensity erosion processes.

474. Obtained data show that mulching of the vineyard terraces stipulates better accumulation and economic moisture usage during the season together with this surface flow and soil erosion do not almost take place. The best mulching effect has yearly application of manure in amount of 20 t ha⁻¹ and hay using as mulch. For this reason in the variations mulched by manure and hay was obtained the highest vineyard yield from 50 to 60 centner ha⁻¹ in dry years and 90-93 centner ha⁻¹ in wet favorable years, while in the control (black vapor) it was made 31-35 centner ha⁻¹.

475. Terraces are the radical agro techniques for regulating the surface flow and soil washout, they help to counteract to not only erosion but to drought as well.

476. Year 2009 was wet, cool with abundant rainfalls (Table 67; Table 69). As a result moisture reserve in all the variations was high. Effective moisture reserve in metric layer has been made under the black vapor 674 m³ ha⁻¹, and under mulch from 987 to 1059 m³ ha⁻¹. Rainfall penetration was more that two meters, in the second meter effective moisture reserve under black vapor has been made 1300 m³ ha⁻¹, under mulch has been made from 1506 to 1644 m³ ha⁻¹ (Table 69).

477. Thus, it was determined that terracing and mulching of the terrace surface by straw and vineyard cuttings are the most effective agro technical techniques for accumulation and economical consumption of the moisture.

Table 67. Effective moisture reserve on the terrace under the vineyards (m³ ha⁻¹) for 2009

Experimental variations	19.04.09				16.05.09			14.06.09			15.07.09				
	0-50	50-100	0-100	100-200	0-50	50-100	0-100	100-200	0-50	50-100	0-100	0-50	50-100	0-100	100-200
Black vapor	+718	+846	+1564	+1962	+675	+1224	+1899	-	+446	+685	+1131	+77	+597	+674	+1300
Mulch hay	+597	+388	+985	+776	+941	+1116	+2057	-	+792	+885	+1677	+337	+650	+987	+1506
Mulch cuttings of vineyards	+818	+927	+1745	+1875	+1048	+1238	+2286	-	+883	+1025	+1908	+419	+640	+1059	+1644

Table 68. Average annual for 2007-2009 amount of rainfall (mm) and air temperature (C^o) in Fayzabad district

Year	Months														
	1	2	3	4	5	6	For the first half of a year	7	8	9	10	11	12	For the second half of a year	Per year
Perennial	90.2	113.0	175.9	137.4	112.5	36.0	665	0.8	9.4	0.0	62.8	62.9	68.5	204.4	869.4
	-0.3	1.0	5.1	11.8	17.6	21.3	9.4	25.5	23.8	19.1	19.5	5.6	2.5	16.0	12.1
2007	73.4	117.5	156.0	41.4	130.5	33.5	553.3	5.3	0.0	0.0	0.0	3.4	136.6	145.3	698.6
	-1.4	3.6	5.23	15.7	18.4	23.6	10.85	24.2	23.3	19.3	11.7	9.7	10.9	14.86	12.9
2008	73.1	101.9	26.2	122.4	30.2	0.0	353.8	2.7	1.3	1.2	3.0	54.8	32.4	95.4	449.2
	-2.01	-2.21	11.6	14.7	18.6	19	10.0	26.0	24.8	16.6	14.6	6.0	4.7	13.8	11.9
2009	40.7	156.3	113.4	307.9	168.6		786.9								
	2.07	2.8	7.7	10.9	16.5		8.0								

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Table 69. Agro techniques at the experimental sites, 2009.

Name of crops	Soils tillage	Date and rate of crop planting	Date of harvesting	Date of fertilizers' application	Date of mulching
1. Experiment at the plots					
1. Winter wheat	Manual digging	20.10.09. 200 kg ha ⁻¹	10.06.09	First application of additional fertilizers during tillering. Second application during booting stage.	
2. Lentil	Manual digging	13.03.09 70 kg ha ⁻¹	8.06.09		
3. Alfalfa of the 2 nd year of the 1 st year	Manual digging	of the 2 nd year 15.03.09 20 kg ha ⁻¹	10.05.09 13.06.09		
1. Industrial experiment №1	Plowing by tractor				
1. Lentil, top 2. Winter wheat, middle 3 Alfalfa, down	of the 2 nd year	15.03.09 70 kg ha ⁻¹ 14.10.09 200 kg ha ⁻¹ of the 2 nd year	8.06.09 12.06.09 13.06.09	During tillering stage ammonium phosphate was applied in calculation for 90 kg ha ⁻¹	
3. Industrial experiment №2	Plowing by tractor				
1. Winter wheat, top 2. Lentil, middle 3. Alfalfa, down	of the 2 nd year	14.10.09 200 kg ha ⁻¹ 13.03.09 70 kg ha ⁻¹ of the 2 nd year	12.06.09 8.06.09 13.06.09	During booting stage 30 kg ha ⁻¹ of ammonium nitrate was applied.	
4. Experiment at the terrace with vineyard	Tillage by plough to 18-22 cm depth				Mulching with hay and vineyards cuttings 10-20.04.09

4.4.4.1 Changes of humus content under the different growing conditions at the terraces.

478. As it was pointed out for the purpose of fighting against soil erosion creation of terraces while planting fruit and vine crops at the lip slopes gives good results. Though as a result of slope terracing top fertile layers are cut and due to this amount of humus and nutrients reduces, hydro-physical and biological soil properties worsen at the bed of terraces.

479. As a result of terracing mother rock comes out to the day surface. Thus, investigation of terrace's bed for humus content shows that during 40 years at the terraced slopes humus content in fact has not changed. At the upper half of meter layer humus content remained at the same level at a range of 0.73-0.79%.

480. During nine years observations has been found out that under the black vapor humus content in the half of meter layer even reduced from 0.73 to 0.64%. Humus does not form without biomass. Under mulch and hay humus content increased from 0.79 to 1.50%, while under mulch with vine cuttings for this period of time humus content remained at the same level of 0.73-0.71 (Table 70).

481. Increasing of humus content at hay mulching connected with hay decomposition and humus formation while at vine cutting mulching decomposition of rude grapevine do not happen so much that is why formation of humus matter is very less.

482. Stability of humus content in black vapor is explained by not considerable amount of biomass accumulation and by extremely low biological activity.

Table 70. Changing of humus content under the different growing conditions at the bed of terraces in vineyard (Faizabad district)

Experimental treatments	29.05.01			14.04.09		
	Depth, cm	Humus, %	Humus reserve, t ha ⁻¹	Depth, cm	Humus, %	Humus reserve, t ha ⁻¹
1. Terrace, black vapor	0-30	0.87	33.93	0-30	0.74	28.86
	30-50	0.50	13.00	30-5-	0.50	13.00
	0-50	0.73	46.93	0-50	0.64	41.86
2. Terrace mulch hay	0-30	0.99	38.60	0-30	1.94	75.66
	30-50	0.50	13.00	30-50	0.84	21.84
	0-50	0.79	51.60	0-50	1.50	97.50
3. Terrace mulch, vineyard cuttings	0-30	0.78	30.42	0-3-	0.86	33.54
	30-50	0.66	17.16	30-50	0.48	12.48
	0-50	0.73	47.58	0-50	0.71	46.02

4.4.5 Conclusions

1. At the terraces different techniques of mulching stipulate considerable accumulation of rainfalls in the soil that makes influence on their effective consumption in comparison with control (black vapor).
2. Terracing and mulching are the radical agro technical techniques for regulating the surface flow and soil washout. They help to counteract not only soil erosion but drought as well.
3. Effective moisture reserve at terracing and mulching sites remains positive till August-September.



Figure 55. Slope lands development with 10-15° inclination by terracing with vine planting



Figure 56. Slope lands development with inclination of 10-15° by terracing with vine planting. Raised-bed mulching of vineyards with vine cuttings



Figure 57. Slope lands development with inclination of 10-15° by terracing with vine planting. Raised-bed mulching of vineyards by hay.

4.5 Tajikistan: Activity 3 Developing Rationale land-use plans for enhancing productivity of degraded sloping lands in low and high rainfall regions

4.5.1 Introduction

483. One of the main tasks of slope land development in conditions of half supply rainfed is lack of rainfalls which negatively influences on the productivity of waste slope lands and agriculture production development. That is why one of the main optimal plans of land utilization is the effective usage of natural resources. In order to prevent degradation of lands because of soil erosion optimal parameters for water regime should be created using the beds terraced slopes by planting the grain and other agricultures crops at the raised-beds of fruit crops..

484. Subject of research is the state farm named after Dj. Rasulov in the Horasan district of Fakhrrabad region of Khatlon province. Site is located at the eastern slope of Aktau ridge, relief is much portioned with different lips at various slopes expositions

4.5.2 Objectives

485. To study the methods for increasing the productivity of waste slope lands in conditions of half supplied rainfed at the terraced slopes.

486. Task of research is: 1. Investigation of soil agro chemical and agro physical rates of the site at the beds of terraces.

2. To plant wheat and safflower at the raised-beds of walnut and pistachio.
3. Investigation of soil moisture in the wheat and safflower crops at the beds of terraces on the raised-beds of walnut.

4.5.2.1 Outputs expected:

- Relative performance of the crops in landscape positions in high rainfall and low RF
- Soil erosion losses reduced
- More efficient use of rainfall and stored soil moisture
- New cropping systems developed according to landscape positions

4.5.3 Materials and Methods

487. Field experiments were carried out in 2008-2009 at the waste slope lands in the zone of dark sierozems where located the zone of low mountain vineyards. Soil and natural conditions in the dark sierozem zone sharply differs from typical sierozems. This middle adyrs are laid with a big thickness of loess like deposition with the lip 10o to 35o. Fakhrrabad district where investigations were carried out constitutes 7610 ha meters above sea level. Height of

experimental point is made 1000 meters above sea level. General inclination is from the north to the south and from the south to the west. At the territory moderately eroded soils constitute 31% of the investigated area of dark sierozems and mainly spreads at the slopes of south west and east expositions with inclination of 8-12°.

488. Humus content in the plough layer is made 1.63%, and gradually reduces downwards at one meter depth and is made 0.29%.

489. Carbonate content of the top layer rises due to the erosion increasing. Average annual amount of precipitations is made 515 mm, number of days with rainfalls is 100, daily maximum is made 60 mm. Precipitations do not almost take place during summer period for 4-5- months. Weather conditions in winter and spring 2008 were not favorable in relation to rainfalls and temperature regime. Precipitations were not equal in the different months. Winter was very frosty; temperature in January was -30o. However starting from the second half of February and till the end of March precipitations have been made only 125 mm with 0.02 mm intensity. During this period in February was observed the highest air temperature to 25°, and low negative air humidity.

490. This led to the sharp reduction of growth, development and formation of grain and other agricultural crops productivity in the zone with dark sierozems, in particular in our experiments with wheat at the beds of terraces.

491. Weather conditions of 2009 in relation to the precipitation and temperature regime for the growth and development of plants in the zone with dark sierozems were very favorable. Amount of precipitation has been made 750 mm. For the vegetation period of winter wheat from March till May rainfall amount was almost 330 mm.

492. Starting from April till the second half of May intensive pouring rain and high relative air humidity were observed at all sites.

493. For this reason in 2009 at all the sites of Fakhrabad districts at grain and other agricultural crops were observed many intensive rains that led to the temperature drop to 20-22o in comparison with 2008 — 25-30o.

494. This rainfall accumulation led to the improvement of wheat and other crops' growth and development at the experimental sites of Fakhrabad district. Investigations over the main hydro-physical soil properties are given in the Table 71.

Table 71. Hydro-physical soil properties

Genetic layer, cm	Total porosity, %	Moisture, %	Moisture reserve, m ³ ha ⁻¹	Granulometric composition (mm), in %		Volume weight, g cm ⁻³
				<0.001	<0.01	
0-16	40.1	3.5	91.8	7.8	36.2	1.30
0-33	38.0	6.2	270.0	7.6	38.1	1.34
0-50	46.5	7.2	497.0	7.4	37.1	1.40
0-83	50.0	8.3	998.0	3.5	34.2	1.45
0-110	46.2	11.2	1848	2.1	32.5	1.50

495. Data from Table 71 show that dark sierozems are very appropriate for good hydro-physical properties. Volume weight is made 1.30 — 1.45 g cm⁻³, porosity is made at the range 40-50%.

496. Field experiments were carried out in February 2008 at the beds of terraces with 3 m width and 8-10° inclination where transplants of walnut were planted according to the scheme:

in 2008

- 1 Control — walnut without planting.
- 2 Walnut + wheat + fertilizers N60.
- 3 Walnut + field pea + fertilizers N60

in 2009

- 1 Control — walnut without planting.
- 2 Walnut + wheat.
- 3 Walnut + safflower + fertilizers N60

497. Measured grounds with wheat and field pea have been made (3 x 10 m)=30m²

498. Grounds were located along the slope. Soil tillage was carried out to 22-27 cm depth along the bed of terrace. Fertilizers were applied under the wheat and field pea of N60 or 180 kg ha⁻¹ of ammonium nitrate with nitrogen content of 34%. Clean nitrogen was applied per 30 kg ha⁻¹ two times in March and April.

499. Wheat of Navruz variety was planted as a seed grain, sowing rate was 180 kg ha⁻¹, field pea of Tadjikskiy variety – 60 kg ha⁻¹. Planting of wheat and field pea was carried out in early spring in February by manual method. Harvesting was done also manually.

500. At the vegetation stage phenological and biometrical observations were carried out at the sites under the wheat and field pea. Amount of shrubs, stems and height were determined at the grounds of 0.25 m² (50 x 50 cm) planted at the top and at the down part of ground.

4.5.3.1 Methodology

501. Filed experiments were accompanied by laboratory analysis of soil samples. Qualitative accounting and observations were carried out for investigating the factors which show the experiment results and explain the reasons of different fertilizers' effect.

1. Height of plants was determined (average of 20-30 measuring according to the stages, booting and fully ripeness).
2. Plant density was taken into account according to the same stages at one square meter.
3. For soil analysis cuttings were done and soil samples were taken from genetic layers. Besides that mixed soil samples were taken from plough layer (0-30 cm).

502. Soil analyses were carried out by generally accepted methods: «Agro chemical methods for soil investigation» (Sokolov, 1960) and methods of agro physical and micro biological investigations in the field cotton regions, Tashkent 1963.

503. From soil samples were determined: humus — according to Tyurin in Simakov modification; general nitrogen according to Keldal; gross phosphorous according to Chirkov and Ginsburg. Content of mineral nitrogen and mobile forms of phosphorous and calcium was determined as follows: nitrates according to the method of Shaferstein, Lipkind, Sava (1962), ammonium nitrogen by Nesler's reactant, mobile phosphorous according to Machigin, exchangeable calcium – on the flame photometer according to Protasov.

504. Rates of soil water regime and dynamics of moisture accumulation according to the stages of wheat and other crops' development were determined directly at the field. Soil moisture was defined by drying samples at 105 degree from each 0-30 cm layer till half of meter depth of three replication from two replications of each experiment.

505. Phenological observations were carried out during wheat and other crops' vegetation.

4.5.4 Results and discussions

506. Research results according to the agro chemical rates (Table 72) show that in plough and sub-plough soil layers at the terraces where experiment was carried out with wheat, field peas and safflower, humus content in the soil layer (0-30 cm) has been made 1.30, gross nitrogen – 0.070, phosphorous – 0.160 and calcium – 1.80%.

507. According to the observation results over the soil moisture under the wheat, field peas and safflower at the terraces where walnut was cultivated moisture content was allocated not equally (Table 73).

508. Data from Table 73 show that the biggest moisture reserves in 0-50 cm layer for 2008-2009 are created in April during booting stage where they have been made 1310 and 1229 m³ ha⁻¹. Thus, moisture reserves were increased for 152 and 71 m³ ha⁻¹ in comparison with control 1158.0 m³ ha⁻¹.

Table 72. Agro chemical and agro physical rates of plowing and sub-plowing soil layers in terraced slope lands at the site with dark sierozems

Soil and experiment place	Crop planting	Soil layer, cm	Humus in %	Gross content, %			CaCO ³	Volume weight, g cm ⁻³
				N	P20 ⁵	K ² O		
Dark sierozem	Wheat	0-30	1.30	0.070	0.160	1.80	18.6	1.35
<i>Полотна</i> terrace Lip 8-10°		30-50	0.95	0.052	0.145	1.55	21.8	1.42
Walnut planting	Field peas + safflower	0-30	1.26	0.080	0.170	1.60	18.6	1.35
		30-50	0.85	0.060	0.150	1.62	21.8	1.42

Table 73. Soil moisture content at the bed of terrace under the wheat and field peas according to the development stage for 2008

Experimental variations	Layer in cm	Booting 23.04.08		Ripening 10.06.08	
		%	m ³ ha ⁻¹	%	m ³ ha ⁻¹
1. Without crop planting	0 - 30	16.5	668.2	3.72	150.6
	30 - 50	17.5	490.2	5.52	155.9
	0 - 50	17.0	1158.5	4.64	306.5
2. Walnut + Wheat + N60 fertilizer	0 — 30	18.6	753.3	3.59	145.3
	30 — 50	19.6	557	6.3	178.9
	0 — 50	19.1	1310	4.94	324.2
3. Walnut + field peas + N60 fertilizer	0 — 30	17.8	720.9	2.89	117.0
	30 — 50	18.2	509	6.39	178.9
	0 — 50	18..0	1229	4.64	295.9

509. According to the Research moisture reserves were reduced from April to June, and in June moisture reserve drops to the minimum rates (from 3 to 5 times).

510. More difference in soil moisture is observed at the variation wheat + N60 as an additional fertilizer (in Table 74 for 2009) from which moisture reserves in these variations remain higher in 1.4 times under the wheat and in 1.8 times under safflower in comparison with control.

Table 74. Soil moisture content at the terraces in dark sierozems under the wheat and safflower according to the development stages

Experimental variation	Layer in cm	Tillering stage 1.04.09		Booting 20.05.09		Ripening	
		%	m3 ha ⁻¹	%	m3 ha ⁻¹	%	m3 ha ⁻¹
1. Walnut without crops' planting	0 - 30	16.21	680.8	17.10	730.8	8.75	367.5
	30 - 50	17.45	506.0	20.10	584.6	9.40	272.6
	0 - 50	16.83	1186.8	18.75	1315.4		640.1
2. Walnut + wheat	0 — 30	17.35	751.2	19.65	825.3	7.92	332.6
	30 - 50	18.45	534.5	27.06	639.7	4.82	139.7
	0 - 50	17.88	1286.4	20.85	1465.04		472.3
3. Walnut + wheat +N60 as additional fertilizers	0 — 30	18.45	904.0	20.75	1016.7	8.67	364.1
	30 — 5	20.50	594.5	28.10	814.9	3.30	95.7
	0 - 50				1831		459.8
Beds of terraces, walnut							
		2 — 3 leaves		booting			
1. Control without crops' planting	0 — 30	14.25	598.5	15.65	657.3	7.82	328.4
	30 — 50	15.52	450.0	16.52	479.0	8.95	259.5
	0 — 50	14.88	1048.5	16.08	1136.3		587.9
2. Safflower without fertilizers	0 — 30	15.05	632.1	24.80	595.4	5.52	231.8
	30 — 50	17.95	520.5	24.54	711.66	6.75	195.7
	0 — 50	16.50	1152.6	24.67	1307.1		427.4
3. Safflower + N60 as an additional fertilizers	0 - 30	16.65	699.3	25.65	1256.8	4.23	177.6
	30 - 50	19.20	556.8	26.52	769.1	10.82	313.7
	0 - 50	17.92	1256.1	26.08	2025.9		491.3

511. One of the most effective methods of fighting against soil erosion at the slopes with dark sierozems is terraced agriculture. One-year and perennial crops can be planted at the lip of 10-25o in terraced method.

512. Research were carried out for wheat and field pea planting at the terrace bed where 6 years old walnut was planted. Implemented experiments (in 2008) showed that growth and development of wheat in the variation walnut + wheat during the booting stage on 23.04.2008 in average has been made 18 cm, and during ripening stage - 25 cm (Starting from the second half of February till 10 April precipitation amount was 125 mm. This led to the sharp reduction of growth and development and to the losses of grain and other agricultural crops in the rainfed zone of dark sierozems due to the moisture shortage in the soil.

513. Experiments showed that due to the strong drought and moisture shortage peas planted at the beds of terraces totally dried.

514. Table 75) because the year was dry and not favorable in relation to rainfalls and temperature regime.

515. Starting from the second half of February till 10 April precipitation amount was 125 mm. This led to the sharp reduction of growth and development and to the losses of grain and other agricultural crops in the rainfed zone of dark sierozems due to the moisture shortage in the soil.

516. Experiments showed that due to the strong drought and moisture shortage peas planted at the beds of terraces totally dried.

Table 75. Phenological observations over the growth and development of grain crops at the beds of terraces in 2008

Experimental variation	Height, cm		Amount of shrubs, pc/m ²	Amount of stems, pc./m ²	Tillering coefficient	Amount of stems at ripening stage, pc./m ²
	Booting	Ripening				
Walnut without planting	-	-	-	-	-	-
Walnut + wheat +N60 fertilizers	18	25	115	180	1.56	160
Walnut + field pea +N60 fertilizers	10	-	80	100	1.25	-

517. According to phenological observations over the growth and development of winter wheat and safflower planted at the bed of terraces (Table 77) were on the contrary, i.e. year 2009 was very favorable in relation to rainfalls and temperature regime where during the vegetation period of winter wheat and safflower from March till May amount of precipitation was almost 300 mm.

518. That is why during the booting stage height of wheat in the variation wheat + fertilizer N60 has been made 65 cm, safflower - 75 cm in comparison with control of 50 cm where both of the crops grew for 15 cm

519. Data from Table 76 show that in both variations agro technical techniques were carried out. Yield of wheat grains was obtained at the beds of terraced lands of Fakhrabad district in conditions of dry 2008 year. In the variation of planting wheat with ammonium nitrate application of 180 kg ha⁻¹ was obtained 15.0 centner ha⁻¹ of grain yield and field pea is totally dried due to the moisture shortage in the soil

520. According to the Table 78 application of clean nitrogen at a rate of 60 kg ha⁻¹ positively influenced on wheat and safflower yield at the terraces in the zone of dark sierozems in 2009

Table 76. Yield of wheat grain in the bed of terraces at the experimental sites of Fakhrrabad district at the raised-bed of walnut in centner ha⁻¹ in dry 2008 year.

Experimental variations	Replication			Average yield in centner ha ⁻¹
	I	II	III	
1. Walnut without planting, control	-	-	-	-
2. Walnut + wheat + fertilizers N60	15.0	14.0	16.0	15.0
3. Walnut + field pea + fertilizers N60	-	-	-	-

Table 77. Phenological observations over the growth and development of winter wheat and safflower at the bed of terraces with dark sierozems

Experimental variation	Height of growth,cm			Amount of shrubs pc./m ²	Amount of stems, pc./m ²	Tillering coefficient	Amount of stems at ripening stage, pc./m ²	
	Tillering 01.04.09	Booting 20.05.09	Ripening 7.07.09					
In the terraces of walnut								
1. Control (without crop planting)	-	-	-	-	-	-	-	-
2. Wheat without fertilizers	15	60	60	180	140	1.40	150	18.00
3. Wheat + N60 as additional fertilizing	18	65	75	150	240	1.60	240	25.0
Bed of terraces with walnut plantings								
	Start of booting 1.04	Booting 20.05	Start of bolls formation					
1. Control without crop planting	-	-	-	-	-	-	-	-
2. Safflower without fertilizers	25	50	70	50	52	1.04		
3. Safflower +N60 as additional fertilizers	35	75	105	67	70	1.04	70	

Table 78. Yield of wheat grain and safflower at the terraces with dark sierozems at the site of Fakhrabad district in centner ha⁻¹

Experimental variation	In favorable 2009				
	Replication			Average yield centner ha ⁻¹	Additions, centner ha ⁻¹
	1	2	3		
Bed of terraces with walnut planting during 6 years					
1. Control without crop planting	-	-	-	-	-
2. Wheat without fertilizers application	16.0	19.0	20.0	18.0	-
3. Wheat with N60 for additional fertilizing	26	24	25	25.0	+7,0
Bed of terraces with walnut planting					
1. Control without crop planting	-	-	-	-	-
2. Safflower without fertilizers application	3.5	4.0	4.7	4.0	-
3. Safflower with N60 for additional fertilizing	8.0	10	9.0	9.0	+5.0

Table 79. Costs for agro technical operations for cultivating the crops (wheat and peas) at the bed of terraces for 2008

Agro technical activities	Traditional method, somoni	Costs for planting technology, somoni
1. Wheat planting with 200 kg ha ⁻¹ seed rate per one hectare. Ploughing at the beds of terraces by tractor.	Not	950
2. Additional fertilizing by nitrogen at a rate of 180 kg ha ⁻¹ , ammonium nitrate in March		360
3. Wheat harvesting from hectare		300
4. Total cost per 1 ha		1610
5. Cost of wheat yield grain - hay -	1500 kg x 2 s 1700 кг x 0,5 s	3000 750
6. Additional net income from 1 ha		2140 s.

521. According to the data from the Table 78 in 2009 feeding conditions were more favorable in the fertilized variations that led to the intensive plants growth and provided high yield. Thus, in the control variations yield of wheat has been made 18.0 centner ha⁻¹ and of safflower - 4 centner ha⁻¹, while at the fertilized variations from 60 kg ha⁻¹ of nitrogen was obtained 25.0 centner ha⁻¹ of grain wheat and 9.0 centner ha⁻¹ of safflower seeds.

522. Thus, at the terraced slope lands crops' cultivation at the beds of terraces with fertilizers application protects slope soils from direct rain drops, from breaking the tops of soil layer and

increases the productivity of crops at the bed of terraces in the zone of dark sierozems. Investigations of effective fund usage for agro technical operations of grains cultivation in the terraces at the raised-beds of walnut (Table 79 and Table 80) show that at correct allocation of perennial plants in the terraced slopes, by planting of grain and other crops in conditions of semi supplied rainfed in Fakhrabad district can be obtained an additional income from one hectare of wheat crop in dry year 2008 - 2140 som, and in favorable year 2009 - up to 2405 som. Besides that it is prevent the erosion spreading and increase fertility of eroded soils.

Table 80. Costs for agro technical operations for cultivating grain and oil-yielding crops (wheat at the bed of terraces), for 2009

Agro technical activities	Traditional method, somoni	Costs for planting technology, somoni
1. Wheat planting with 200 kg ha ⁻¹ seed rate per one hectare. Plowing at the beds of terraces by tractor.		950
2. Additional fertilizing by nitrogen at a rate of 180 kg ha ⁻¹ , ammonium nitrate in March		360
3. Wheat harvesting from hectare		350
4. Total cost		1660
5. Cost of wheat yield		3000 s
grain -	25 c x 1,2 s =	1065 s
hay -	35 c 0,30 s =	4065 s – 1660 = 2405 s
6. Additional net income from 1 ha	900 kg x 4 c = 3600 – 1660 s	1940 s
7. Additional income from safflower seeds yield from 1 ha		1040 s

Table 81. Expected result from taking agro technical erosion-preventive measures by planting grain and other agriculture crops at the beds of terraces in conditions of Fakhrabad district in the zone of half supplied rainfed

Obtained results	Expected result was obtained from this techniques
<p>1. For sustainable usage of slope lands and for development of agricultural system.</p> <p>Obtained results:</p> <p>1. Wheat, field pea and safflower were planted at the beds of terraces while cultivating the forest fruit crops at the raised-beds of walnut</p> <p>2. Fertilizers application at a rate of 180 kg ha⁻¹, and application of ammonium nitrate in March.</p>	<p>As a result of the given technique:</p> <p>1. Erosion process reduced, moisture reserve increased in 1.5-2 times in 0-50 cm soil layer.</p> <p>2. Growth and development of wheat and safflower increased thank to fertilizers application.</p> <p>3. Additional grain yields of wheat from 15 to 25 centner ha⁻¹ and of safflower up to 9 centner ha⁻¹ were obtained that has been made 2405 som net income from wheat and 1940 s. from safflower.</p>

4.5.5 Conclusions

523. It is determined by the Research that at the beds of terraces where ploughing was carried out for wheat and field pea planting in not favorable year for growth and development, moisture reserve was observed in 0-50 cm layer of soil and has been made 1310 and 1229 m³ ha⁻¹. Increasing has been made for 152 and 71 m³ ha⁻¹ more in comparison with the variation without crops planting.

524. According to the results of two years observations over grain wheat yield at the bed of terraces in the variation wheat and safflower with 60 kg ha⁻¹ nitrogen application, 15 centner ha⁻¹ of grain yield was obtained in 2008 and 25 centner ha⁻¹ in 2009 in comparison with control.

525. In 2008 net income was obtained at a rate of 2140.1 som and in 2009 at a rate of 2405.0 from wheat planting, and nitrogen fertilizers and net income at a rate of 1940 s from safflower.



Figure 58. General view of safflower and winter wheat at the bed of terraces with walnut and pistachio at the raised-beds, Fakhrabad site



Figure 59. Fertilizers effect on the growth and development of: 1 - safflower without fertilizers, 2 - safflower with N60 application, 3 - wheat with N60 application



Figure 60. Pistachio yield at the terraces, Farkhabad site



Figure 61. Expected result. Condition of small-leaved oleaster and pistachio at the terraces, Fakhrabad site

4.6 Tajikistan: Activity 4. Evaluate the efficacy of mechanical and vegetative measures for gully erosion control and rehabilitation of degraded sloping lands

4.6.1 Introduction

526. Ravine erosion became widely known in the Republic as a result of intensive development of slope lands at present time. The main reason of ravines' high density is reclamation of lip slopes without taking erosion-preventive measures, wrong irrigation, intensive grazing, lip slopes plowing along the slope, wrong discharge of potable water at the mountain slopes and other anthropogenic factors (Akhmadov 1982).

527. Forest and phyto-meliorative plants near the ravines play an important role in the system for fighting against soil erosion. Reclamation value of such phyto reclamation and forest lines is wide and diversified.

528. They impact on the microclimate of adjacent croplands, stipulate the reduction of snow blowing from the slopes, regulate the surface flow and soil erosion. During the period of snow melting, plants which are close to ravine consume melt water in 10 or more times more than the slope soils without forest field. Surface flow, having run along these forest and shrub lines cleans from sediments of drain waters.

529. Being strongly mixed with each other in the soil, root systems of forest, shrub and grass cover form quite powerful network of roots, which strengthens the soil resistance against erosion processes. Under the influence of plantings air climate softens, relative air humidity increases in average for 5-15%, as a result of this physical evaporation reduces for 12-16% that is positively effects on the growth and development of agricultural crops, increases their productivity and all of this leads to economical water usage and reduction of the rates of irrigation water.

530. Besides that tree and shrub plantations, shading the sunny banks and ravine slopes as well as stipulating the moisture thank to soil permeability improvement by directing surface flow inside the soil, create the favorable conditions for development of grass plants and tree and shrub crops themselves.

4.6.2 Objectives

531. The main purpose of implemented research is to investigate the conditions of soil processes occurrence and development and to work out phyto-reclamation activities in ravine zone by planting different shrub crops.

532. The following tasks were determined in accordance with given purpose:

1. To study various phyto-reclamation activities and their efficiency in reducing the surface flow and soil erosion.

2. To determine an efficiency of phyto-reclamation activity for fertility rehabilitation of waste ravine soils.

4.6.2.1 Outputs expected

- Best tree species identified for gully rehabilitation
- Gabion construction for gully rehabilitation will be introduced
- Cost benefit analyses of sole / combined vegetative and technical measures
- Nitrogen fixing shrubs will be identified

4.6.3 Materials and Methods

533. In order to determine the efficiency of different shrubs for protecting the ravines from further degradation various shrubs were planted at three ravines according to the following scheme:

1. Ravine without phyto-reclamation (control);
2. Ravine with planting the transplants of Spanish broom;
3. Ravine with planting the transplants of cercis;
4. Ravine with planting the transplants of wild cherry.

534. In all ravines at the upper and middle parts was built chabon stone wall to hold flow and soil washout. At the end of 2008 concrete blocks of one meter height were built at the end of ravine for accounting total surface flow and soil washout in whole ravine. Accounting of fluid flow was carried out by volume method and accounting of soil washout was done by measuring a sedimentary soil (sediment) before concrete block.

4.6.4 Results and discussion

535. Soil and water resource management play the key role for providing long-term and effective production at the slope lands which serve as protective measure for environment retention and for degradation process prevention.

536. Wrong lands usage as in mountain zone so in flat irrigated lands led to a big ravine formation. As a result of this, big areas of plowing lands, rained zones and irrigated lands are not used in the agriculture and turn into waste lands. Great efforts and taking various technical and phyto reclamation measures for preventing further degradation, ravine widening and erosion processes in field conditions are required their improvement.

537. Various technologies should be studied for this purpose in order to show them to the farmers: phyto reclamation, forest reclamation and technical activities which stipulate the rational resource usage and hold up further ravine degradation

538. According to research results content of organic matters in mountain brown carbonate soils at planting bottom and borders of ravines by shrubs increased and organic residues of above-ground and root mass of high mountain planting are accumulated.

539. Legumes and cereal plants intensively grow under the shrubs canopy, humus condition of soil improves and erosion processes considerably hold up.

540. Data of humus content in half of meter layer (Table 82) show that the highest humus content is observed under wild cherry (1.88%) and under Spanish broom and cercis its amount is almost similar (1.80-1.76%), while in the control (without shrub planting) humus content has been made 1.15%. At the same time content of nutrient elements nitrogen and phosphorous remains very low (Table 83).

541. All these show that ravine soils are much degraded. That is why mineral fertilizers should be applied for improving the nutrient regime of plants and for better growth and development of tree and shrub crops.

Table 82. Content of nutrient elements at different ravine phyto reclamation for 27.08.2008

Experimental variation	Depth, cm	N – N03 mg kg-1	N – NH4 mg kg-1	Mineral nitrogen	Mobile	
					P205 mg kg-1	K20 mg/100 g
Ravine №1 Control Herbs	0-10	6.10	22.99	9.90	10.52	30.25
	10-30	5.83	12.82	7.41	5.19	17.25
	30-50	5.12	9.36	6.08	4.18	12.65
	0-50	5.60	13.47	7.48	5.85	18.01
Ravine №2 Spanish broom	0-10	6.76	15.02	8.63	6.78	17.75
	10-30	6.41	10.31	7.29	4.71	18.9
	30-50	6.68	10.26	7.31	3.57	15.15
	0-50	6.59	11.23	7.57	4.67	17.17
Ravine №3 Cercis	0-10	14.48	10.68	13.63	8.13	28.45
	10-30	8.16	2.18	6.82	4.20	15.55
	30-50	7.53	1.73	6.23	8.90	13.75
	0-50	9.17	3.70	7.95	6.87	17.41
Ravine №4 Cherry	0-10	7.85	9.46	8.22	6.46	26.95
	10-30	14.35	7.85	12.91	4.68	21.25
	30-50	13.18	7.06	11.82	3.64	20.30
	0-50	12.58	7.86	11.53	4.62	22.01

Table 83. Humus content at different phyto-reclamation methods in the zone of mountain brown carbonate soils of Faizabad district, % (20-23.09.2008)

Experimental variation		Depth, cm			
		0-10	10-30	30-50	0-50
Ravine №1 control Not planted ravine	A	1.34	1.27	0.77	1.08
	B	1.71	0.60	0.46	0.77
	C	2.27	1.31	0.80	1.30
	D	1.96	1.83	0.83	1.45
In average for ravine	-	1.82	1.25	0.72	1.15
Ravine №2 Spanish broom	A	3.39	1.65	1.58	1.97
	B	2.43	1.83	1.27	1.73
	C	2.14	1.55	1.47	1.64
	D	2.27	2.04	1.45	1.85
In average for ravine	-	2.56	1.77	1.44	1.80
Ravine №3 Cercis	A	4.08	2.14	1.60	2.31
	B	2.69	2.04	1.19	1.83
	C	2.80	1.52	1.21	1.65
	D	3.08	0.83	0.70	1.23
In average for ravine	-	3.16	1.63	1.18	1.76
Ravine №4 Cherry	A	2.53	2.25	1.91	2.17
	B	3.33	2.48	1.83	2.39
	C	1.32	0.96	0.75	0.95
	D	2.64	1.96	1.71	2.00
In average for ravine	-	2.46	1.91	1.55	1.88

Note: A – top of ravine, B – middle part, C – down part,
D – bottom of middle.

4.6.5 Conclusion

542. Thus, phyto-reclamation activities stipulate ravine fixing for fighting against ravine soil erosion and further ravine degradation in rainfed zone. Phyto-reclamation allows improving grass cover that helps to rehabilitate eroded ravine slopes, improving a water regime and physical properties of slope lands, nutrient regime and humus soil condition.

4.7 Tajikistan - Activity: Introduction of scientific-technical designs to the production

543. In 2008 mulching technology was introduced to deqhkan farm “Mozory Khazraty Sulton” of Khovalin district at the area of 0.6 ha for effective moisture consumption at the slope lands under the gardens.

544. Technology of crop allocation in line was introduced to deqhkan farm “Sarsybulok” of Muminabad district at the area of one ha for moisture content and soil protection against erosion.

545. As a result of introducing the line crop planting, income has been made 300 somoni in spite of dry year 2008.

546. In 2009 also both technologies were introduced to two deqhkan farms in Shurobod district of Khatlon province.

547. At the second site experiment was carried out at the slope lands of the same district with 10-15o inclination at the area of one ha in dekhkan farm of Safar Abdukholik.



Figure 62. Phyto-reclamation of ravines



Figure 63. Ravine with wild cherry planting, at the end of ravine concrete block made of crushed stone.



Figure 64. Ravine planted with Spanish broom.

4.8 Tajikistan: Activity 5. Calibration and use of Optical crop canopy sensors (Greenseeker) for measuring crop development over time and space, comparing crop management practices for SLM and efficient nitrogen management

4.8.1 Introduction

548. Wheat is the main industrial crops in many world countries. Provision of grain independence in Tajikistan is very important for obtaining a real sovereignty in the republic, because for a long time food problems were solved by importing them from other countries.

549. Provision of livestock production by concentrated forage, industry by raw material, creation of necessary state reserves and resources for export depend on grain farming development. In the Program adopted by the Government of the Republic of Tajikistan is envisaged grain production increasing up to 1 million 200 thousand tons per year till the year 2015. In this relation in medium-term program of overcoming the crisis of APK in the republic of Tajikistan and priority directions of its branches development strategies till 2010 also grain production increasing more than 2 times is envisaged in comparison with 2005.

550. It is particularly actual for our republic where mountains constitute considerable areas (93%) with different surface inclinations and absolutely high points from 300 to 7495 meters above sea level. Mountain regions of the republic have big land reserve for increasing the areas of arable lands and perennial plantings.

551. Wheat is the most important crop of irrigated agriculture which takes one the main places in planting structure. Thank to high productivity, low net cost and nice taste of obtained products it serves as the main industrial crop at the territory of our country. In Tadjikistan among grain spiked crops in the structure of planting areas wheat has the highest specific weight. Solving this issue could help to find out the conditions which stipulate obtaining of high and economically profitable wheat yield in these soils.

4.8.2 Objectives

552. Purpose of research is to determine the rate of nitrogen fertilizers application, correctly to fix the time of fertilizers' application and to determine optimal wheat productivity as well as the cost for fertilizers application in irrigation and rainfed conditions of the Republic of Tajikistan.

4.8.3 Materials and Methods / Results

553. Calibration and usage of optical sensor (Green Seekers). Methods based on the measurement of red spectrum reflection (for chlorophyll content) and close infrared spectrum area (defined by vegetation) of electro magnetic radiation were used for the assessment of

nitrogen demand during vegetation period. Such methods are based on nitrogen consumption and potential productivity. At present time it was determined that measurement method of Normal differential vegetation index (NDVI) based on the seasonal sensor's indications can be used for prognosis of biomass, nitrogen content and consumption.

554. The following analyses, calculations and observation were carried out:

- morphological soil description till 200 cm depth;
- plants' density was determined two times after germination and at the end of vegetation;
- nitrate and ammonium nitrogen according to the method of Shaffershtein – Lipkind – Savva.
- humus determination by Tyurin's method;
- mobile phosphorous and calcium in the soil according to Machigin's method;
- observations over the growth, development and productivity of wheat in all the experimental variations were carried out according to the methodology of SoyuzNIHI (1981) and B.A. Dospekhov.

555. Research was carried out at the territory of experimental site Obi-Kiik of Khuroson district with local released variety. Field experiment was carried out according to the following scheme

Table 84. Experimental scheme of the variations according to the calibration of nitrogen fertilizers application at rainfed Obi-Kiik site of Khuroson district.

Variations	Rate kg N ha ⁻¹	Application rates of nitrogen fertilizers			
		1- application 50% (at planting)		2 – application 50% (tillering stage)	
1	0	0	0	0	0
2	30	15	113.4	15	113.4
3	60	30	226.8	30	226.8
4	90	45	340.2	45	340.2
5	120	60	453.6	60	453.6
6	150	75	567.0	75	567.0

556. Total area of experimental site is 798 m², four replications, six variations, plot length is 7 m, plot width is 3.6 m, and total plot area is 25.2 m². The following dosages of nitrogen fertilizers (ammonium nitrate 34%) were used in rainfed zone: 0;30;60;90;120;150 kg ha⁻¹; According to the experimental scheme we took the site enriched by nitrogen (250 kg ha⁻¹), with 7 m length, 3.6 m width and also farm site with 25.2 m of plot's total area for comparing the data.

557. The first N rate, ammonium nitrate of 50% was applied at planting on 18 October 2008, stage (F-1), second rate of nitrogen 50% was applied at the moment of three leaves and stem appearing on 31 March 2009, and stage (F-3) according to the experimental scheme.

558. The second rate was applied at the moment of five leaves and development of main and side stems (F-3), tillering stage on 31.03. 2009. The first measurements by Greenseeker was carried out on 20.03.2009. The second measurement was carried out at the moment of 5 leaves appearing and development of main and side stems (F-3), tillering stage on 31.03. 2009. The third measurement was carried out at the moment of leaf sheath's formation and first node appearing, booting stage on 11.04.2009. The fourth measurement was carried out at booting stage of second node and flag leaf ear appearing on 21.04.2009 (brown rust and powdery mildew appeared). Fungicide Impact was applied. The fifth measurement was carried out on 02.05.2009, at the end of booting stage (budding of leaf sheath). The sixth measurement was carried out on 12.05.09, during earing stage (ear appearing). The seventh measurement was carried out on 23.05.2009, during flowering stage (end of flowering), grasshopper plague was observed in some places. The eighth measurement was carried out on 05.06.2009, during milky ripeness stage (ripe grain).

559. Research was carried out at the territory of Obi-Kiik site of Horasan district with "Navruz" wheat variety with applying different rates of nitrogen fertilizers (ammonium nitrate 34%). First rate of 50% nitrogen fertilizers was applied during wheat planting. Second rate of nitrogen fertilizers was applied during tillering stage.

560. "Navruz" wheat variety was bred in Tajik scientific-research institute of agriculture by individual selection from initial material obtained under the influence of photograph conditions on winter wheat "Mironovskaya-yubileynaya" variety which was introduced to the districts of the republic of Tajikistan in 1982. Eritrospermum variety is intensive type, mid-season, resistant to lodging, relatively winter proof. Not too much affected by rust, stinking smut – below the average. Weight of 1000 pc of grain is 39-44 g., straw is very firm resistant to lodging.

561. Experiment with applying different dosage of nitrogen (ammonium nitrate 34%) for Greenseeker calibration was carried out in the irrigated and rainfed zones of Obi-Kiik site of Horasan district of Khatlon province.

562. First 50% N rate (ammonium nitrate 34%) was applied at planting during the stage (F-1), second rate of nitrogen fertilizers was applied at the moment of five leaves appearing and development of main and side stems, tillering stage (F-3) on 31 March 2009.

4.8.3.1 Study site

563. The study was conducted in the Horasan district of Khatlon province. Obi Kiik valley lengthens from the north to the south in parallel to Yavan valley to the west from it and opens to the Vakhsh valley to the Northern-western side of Kuybishev district. It has curve stretch form. Its width in the northern-western side of Kuybishev district varies from 7 to 8 km and in

northern gets narrow to 2 km. Length of valley reaches 25 km. Total area of flat part of valley is about 10 thousand ha.

564. Plantings' cover is represented by low grassed semisavanna with considerable prevalence of ephemeral.

4.8.3.2 Climatic conditions

565. Climate as one of the factors which defines directions of geological and biological processes and consequently soil formation processes is very important for characteristics of simple sierozems of Obi-Kiik valley. Climate in the valley in general is sharply continental which is inherent to the central and south district of Tajikistan. Climate in Tajikistan is characterized by daily and seasonable temperature fluctuation, intensive solar radiation, air dryness and small cloudiness. The main features characterizing thermal regime of the area is monthly and annual average temperatures and duration of frost-free period. These rates are given in the Table 85.

Table 85. General climatic factors of Obi-Kiiksk valley (2208-2009).

Name of weather station	Climate elements	Months									Per year
		IX	X	XI	XII	I	II	III	IV	V	
Kurgan-tyubinsk weather station	Air temperature, C ⁰ , Ab. max.	23.2	34.8	16.8	20.2	17.3	19.2	28.5	29.1	37.0	25
	Ab. min	36.0	8.1	5.3	-4.4	-3.9	-1.2	4.7	3.0	10.9	11-
	Rainfalls, mm	0.0	10.4	11.8	28.2	36.0	57.2	30.3	70.0	437	680.9

566. One of the most important elements of climate is precipitations. According to the amount and frequency of precipitations areas of our investigations can be referred to the zone of rainfed with moderate supplied moisture. According to the data (Table 2) annual amount of precipitation is more than 600-680 mm, and the most amounts of rainfalls are in spring – 540 mm and the biggest are in May. Spring rains are connected with cyclone passage and have a thunderstorm character. The least amount of rainfalls is in summer. Precipitations in autumn are not equal and very rare. Winter rains are long and not abundant, snow falls not so much.

4.8.3.3 Soil of the site

567. Typical sierozems were investigated in Obi-Kiik valleys which were formed on loess-like loamy sediments. Main feature of typical sierozems is clear isolation of humus and carbonate layers. Soil boils from HCl impetuously. Mechanical composition mainly consists of middle loams. Groundwater are laid deeply. Morphological description of cutting carried out at the experimental site is given for characterizing simple sierozems of Obi-Kiik valley.

4.8.3.4 Morphological description of one of typical sierozems

568. A soil profile assessment was done at the leveled water divided place with wheat crops at irrigated site. During the research wheat was at the stage of complete ripeness. Density is good. Pit was bored at the leveled place in southern-eastern part of the site in 50 m from highway and in 55 m from irrigation chute.

Soil profile №1 (description)

0 ---30 cm – dark-gray, small cloddy, not packed, many roots of molded plants, middle loamy, dry, traces of soil digging insects are visible, gradual transition.

30---65 cm – gray, middle loamy, small cloddy, small roots of plants, lightly packed, dry, gradual transition.

65---96 cm – light-gray, middle loamy, carbonates as white-eye, layer is less packed, roots of different sizes, structureless, gradual transition.

96---128 cm – loess-like loams, fresh, light gray with tints of yellow, mellow, structureless, rare thin roots, carbonates as white-eye.

128---200 cm – homogeneous loess-like loam, fresh, light gray, structureless, rare thin roots, rare albescent particles of carbonate salts.

569. Humus content is poor in the soils of experimental site (Table 86) and is made 1.05% in 0-30 cm layer, further it reduces by layers to 0.18%. Major part of nitrogen nitrate contains the top 0-30 cm layer and is made 16.8 mg kg⁻¹ and further reduces by layers to 2.4 mg kg⁻¹. Middle and down layers contain small amount of nitrate nitrogen that is why young plants do not have enough nitrogen. Ammonium nitrogen is not so much in the soil and reduces by layers from 5.04 to 0.72 mg kg⁻¹. According to the content of mobile phosphorous these soils are moderate supplied and its quantity is mainly contained at the top layers of 17.9-23.0 mg kg⁻¹. According to the content of mobile calcium soils of experimental site are poor and moderate requires the calcium fertilizers. Thus, results of analyses show that soils of the experimental site according to the content of mineral nitrogen are referred to poor supplied, according to the mobile phosphorous to middle supplied and according to the mobile calcium to poor supplied.

Table 86. Content of gross and mobile forms of nutrient elements in the soil. (2008-2009).

Place of taking and sample characteristics	Depth, cm	Humus, %	Mobile forms, mg kg ⁻¹		mg kg ⁻¹ , P ₂ O ₅	mg kg ⁻¹ , K ₂ O
			NO ₃	NH ₄		
Cutting -1 Khuroson district, dark sierozem	0-30	1.05	16.8	5.04	17.9	136
	30-65	0.67	6.8	2.04	23.0	94
	65-96	0.32	4.8	1.44	5.5	80
	96-128	0.22	3.8	1.14	2.4	64
	128-173	0.20	2.6	0.84	2.7	52
	173-200	0.18	2.4	0.72	3.6	44

Phenological observation

570. Phenological observations were carried out for describing the process of plants' development. General results of phenological observations over conditions of 2008-2009 are as follows: 1) Planting date – 18 October 2008, 2) Germination – 28 October 2008, 3) Tillering – 25 November 2008, 4) Booting -16 April 2009, 5) Earring -12 May 2009, 6) Flowering -25 May 2009, 7) Milky ripeness - 05 June 2009, 8) Waxy ripeness - 20 June 2009, 8) Complete ripeness - 02 July 2009.

571. Climatic conditions of this year made a great influence on the main stages passing. Big amount of rainfalls, relatively low temperature and other negative factors stipulated the prolongation of vegetation period to 254 days.

Table 87. Effect of nitrogen fertilizers rate on the structure of wheat yield. Rainfed (boghara) (2008-2009).

Treatments	Rate kg Nha-1	Height of plants, cm	Ear length, cm	Productive bushiness	Weight of 1000 seeds. g
1	0	103	5.2	2.1	36.6
2	30	97	5.2	2.1	36.8
3	60	93	5.4	2.0	35.2
4	90	106	5.5	2.1	36.1
5	120	108	5.7	2.3	37.3
6	150	98	5.9	2.5	37.9
1	0	86	5.1	2.2	35.1
2	30	105	5.1	2.4	35.1
3	60	101	5.3	2.6	36.2
4	90	107	5.5	2.6	36.5
5	120	104	5.4	2.8	37.0
6	150	106	5.8	2.7	36.6
1	0	103	5.2	2.3	35.1
2	30	104	5.4	2.3	35.2
3	60	109	5.5	2.5	36.1
4	90	102	5.6	2.6	38.0
5	120	104	5.5	2.6	37.2
6	150	112	5.7	2.8	37.5
1	0	104	5.2	2.2	35.1
2	30	102	5.1	2.1	35.2
3	60	106	5.0	2.4	35.5
4	90	103	5.6	2.6	37.2
5	120	102	5.7	2.7	37.3
6	150	107	5.9	2.8	37.4

572. According to the data of Table 87 various rates of nitrogen fertilizers make and influence on the structure of wheat yield differently. At raising the rate of nitrogen fertilizers height of plants increases from 86 cm to 108 cm and weight of 1000 seeds increases from 35.1 to 38.0 g. Different rates of nitrogen fertilizers have a very good effect on the wheat productivity (Table 88). Thus, wheat productivity has increased when the rate of nitrogen fertilizers (ammonium nitrate 34%) was raised in all variations. In control variation it has been made from 18.4 to 19.5 centner ha⁻¹, and in the variations of raised nitrogen rate (150 kg ha⁻¹) from 24.5 to 25.8 centner ha⁻¹. The highest yield was obtained in the variation 6, where it has been made 25.8 c. At the site with enriched nitrogen we obtained 25.4 centner ha⁻¹ as in the variation 6 from each replication, and at the farmer's site where N50 kg ha⁻¹ was applied, yield has been made 23.2 centner ha⁻¹.

Table 88. Effect of nitrogen dosage on the productivity of wheat grain, centner ha⁻¹. Experimental site Obi-Kiik of Horasan district, rainfed (2008-2009)

Experimental variation	Dosage of nitrogen fertilizers	Replications				Enriched N ₂₅₀ kg ha ⁻¹	Farm site
		I	II	III	IV		
1	0	18.4	18.5	19.5	18.6	25.4	23.2
2	30	19.0	20.1	20.0	20.3		
3	60	23.3	23.5	22.9	22.9		
4	90	23.4	24.2	24.0	23.8		
5	120	24.6	24.7	24.4	24.6		
6	150	24.5	25.2	25.4	25.8		

4.8.3.5 Irrigated experimental site Obi-Kiik of the Horasan district

573. Total area of experimental site is 798 m², 4 replications, 6 variations, length of plots is 8.4 m, width of plots is 3 m, and total area of plots is 25.2 m². The following dosages of nitrogen fertilizers (ammonium nitrate 34%) were used in rainfed zone: 0;50;100;150;200;250 kg ha⁻¹.

574. The first N dosage, ammonium nitrate of 50% was applied at planting on 28 October 2008, stage (F-1), second dosage of nitrogen 50% was applied at the moment of three leaves and stem appearing on 31 March 2009, stage (F-3) according to the experimental scheme.

Table 89. Experimental scheme of experimental variations according to the calibration of nitrogen fertilizer application in the irrigated zone of the Horasan district

Variations	Rate N kg ha ⁻¹	Rate of nitrogen fertilizers application			
		1- application 50% (at planting)		2 – application 50% (tillering stage)	
1	0	0	0	0	0
2	50	25	189	25	189
3	100	50	378	50	378
4	150	75	567	75	567
5	200	100	756	100	756
6	250	125	945	125	945

575. The first measurements by the greenseeker was carried out on 20.03.2009. The second measurement was carried out during tillering stage on 31.03.09. The third measurement was carried during booting stage, appearing of the second node and flag leaf on 11.04.2009. The fourth measurement was carried out at booting stage, (ear appearance of flag leaf and swelling of leaf sheath), end of booting stage on 21.04.2009. Nidus of brown rust appeared, Fungicide Impact was applied. The fifth measurement was carried out on 02.05.2009, at the end of booting and earring stage (appearance of first spike). The sixth measurement was carried out on 12.05.09 during flowering stage (end of flowering) in the variations where 200; 250 kg ha⁻¹ N were applied wheat lodging was observed in some places due to a very rainy season. The seventh measurement was carried out during the stage of milky ripeness (ripe grain), height of plant 120-135 cm. The eighth measurement was carried out during waxy ripeness (solid grain) on 05.06.2009.

4.8.3.6 Morphological description of one of the typical sierozem pits.

576. Cutting was carried out on wheat plantings at the rainfed site. At the moment of investigation wheat was at the stage of full ripeness. Pit was bored at the slope area of western-southern part in 250 m from main road Dushnbe-Kurgan-Tyube and approximately in 25 m from rural road. Relief is wavy, mezorelief is of lowering. General inclination (not so big) is to the northern direction of the site.

Soil profile №2

0 ---25cm – dark-gray, dry, of small cloddy, lightly packed, some roots of molded plant, middle loamy, not wet, traces of earth digging insects are visible, gradual transition of colors and clear for composition and moisture.

25---65 cm – gray, middle loamy, small cloddy, small roots of plants, lightly packed, poor moistened, gradual transition.

65---105 cm– light-gray, middle loamy, carbonate excretion as white-eye, layer is of less density, roots of different sizes, structureless, gradual transition.

105--200 cm – loess like loams, fresh, light-gray with tints of yellow, rare thin roots, carbonate as white-eye.

Phenological observations

577. Main results of phenological observations for 2008-2009:

- Planting - 02 November 2008
- Germination - 12 November 2008
- Tillering - 30 March 2009
- Booting - 15 April 2009
- Earring - 05 May 2009
- Flowering - 12 May 2009
- Milky ripeness - 24 May 2009
- Waxy ripeness - 05 June 2009
- Complete ripeness - 25 June 2009.

578. Calculations and observations showed that different rate of fertilizers made a great effect on the plants' height. As can be seen from the Table 90 in all variations where rates of nitrogen fertilizers were increased (250 kg ha⁻¹) height of plants reached 128 cm. In the control variation where fertilizers were not applied, height of plants was from 80 to 105 cm (Table 91) Measurements showed that different rates of nitrogen fertilizers considerably influence on the weight of 1000 seeds. In the control variations where increased rates of nitrogen fertilizers were applied the weight reached 33.6 g.

Table 90. Effect of nitrogen fertilizers on the structure of wheat yield (2008-2009)

Treatment	Rate N kg ha ⁻¹	Height of plants, cm	Length of spike, cm	Productivity of tilling capacity	Weight of 1000 seeds, g
1	0	80	6.2	2.4	32.1
2	50	100	6.2	2.3	32.2
3	100	110	7.1	2.1	33.2
4	150	90	7.3	2.2	32.1
5	200	101	7.3	2.4	33.3
6	250	105	8.0	2.6	33.5
1	0	105	6.0	2.2	32.0
2	50	135	6.2	2.4	32.3
3	100	120	7.1	2.5	33.2
4	150	110	7.6	2.5	33.1
5	200	121	7.6	2.7	33.4
6	250	132	8.0	2.9	33.6
1	0	86	6.4	2.4	31.5
2	50	95	6.7	2.3	32.0
3	100	120	6.6	2.6	32.1
4	150	98	7.1	2.5	33.2
5	200	110	7.3	2.7	33.4
6	250	115	7.5	2.9	33.3
1	0	103	6.3	2.2	32.1
2	50	140	6.3	2.5	32.1
3	100	120	6.5	2.5	33.3
4	150	131	7.4	2.6	33.2
5	200	102	7.2	2.6	33.3
6	250	128	7.4	2.8	33.4

Table 91. Nitrogen fertilizers' rates effect on the productivity of wheat grain, centner ha⁻¹. Experimental site Obi-Kiik, irrigation. (2008-2009).

Experimental variations	Rate of nitrogen fertilizers	Replications				Enriched N ₂₅₀ kg ha-1	Farm site
		I	II	III	IV		
1	0	23.4	23.4	23.5	23.4	32.8	26.9
2	50	24.0	24.2	24.4	24.3		
3	100	25.7	25.6	25.9	25.8		
4	150	26.8	26.9	27.0	26.8		
5	200	29.6	28.5	28.4	29.6		
6	250	32.5	32.2	33.4	32.8		

4.8.4 Conclusions

579. Application of N 250kg ha⁻¹ is optimal and reasonable at wheat planting on dark sierozems soils of Horasan district. High wheat yield of 33.4 centner ha⁻¹ was obtained at application of N250 kg ha⁻¹. In the variations where we applied N150-200 kg ha⁻¹ yield was not higher than 26.9-29.6 centner ha⁻¹ without irrigations. At the farm site where were not applied any other fertilizers except N100 kg ha⁻¹ farmer harvested 26.9 centner ha⁻¹ of yield wheat without irrigating.



Figure 65. Field experiment implementation at the rainfed site Obi-Kiik of Khuroson district



Figure 66. Mineral fertilizers application at the rainfed site Obi-Kiik



Figure 67. Wheat measurement by Greenseeker at the rainfed site Obi-Kiik of Khuroson district



Figure 68. Morphological description of soil cutting in dark sierozems of the Horasan district



Figure 69. Wheat harvesting at the experimental site Obi-Kiik of the Horasan district, boghara, 2008-2009.



Figure 70. Field experiment implementation at the irrigated site Obi Kiik of the Horasan district



Figure 71. Measurement of mineral fertilizers at the irrigated site of the Horasan district



Figure 72. Harvesting at the irrigated site Obi-Kiik of the Horasan district.

4.9 Tajikistan: Experiments conducted at the Faizabad district site

4.9.1 Introduction

580. Wheat is one of the oldest crops in agriculture. Exact time of its domestication is not determined; however it is known that it had been cultivated in Europe and Asia approximately in 4-6 centuries B.C. Wheat takes a leading place for productive value and production scale. Production of this crop in all the continents is made 615 million tons. Canada, USA, China, India and Russia produce almost half part of wheat grain. Wheat has always been the main industrial crop of many world countries.

581. Republic of Tajikistan has the purpose to increase the average annual volume of gross products for 12-14%, mainly for the account of intensive development factors and introduction of new achievement of science, techniques and advanced practice.

4.9.2 Objectives

582. Purpose of research is that in irrigation and rainfed conditions of the Republic of Tajikistan to determine the rate of nitrogen fertilizers application, correctly to fix the time of fertilizers' application and to determine optimal wheat productivity as well as the cost for fertilizers application.

4.9.3 Materials and Methods

583. Calibration and usage of optical sensor (Greenseeker). Methods based on the measurement of red spectrum reflection (for chlorophyll content) and close infrared spectrum area (defined by vegetation) of electro magnetic radiation were used for the assessment of nitrogen demand during vegetation period. Such methods are based on nitrogen consumption and potential productivity. At present time it was determined that measurement method of Normal differential vegetation index (NDVI) based on the seasonal sensor's indications can be used for prognosis of biomass, nitrogen content and consumption.

584. The following analyses, calculations and observation were carried out:

- morphological soil description till 200 cm depth;
- plants' density was determined two times after germination and at the end of vegetation;
- nitrate and ammonium nitrogen according to the method of Shaffershtein – Lipkind – Savva.
- humus determination by Tyurin's method;
- mobile phosphorous and calcium in the soil according to Machigin's method;
- observations over the growth, development and productivity of wheat in all the experimental variations were carried out according to the methodology of SoyuzNIHI (1981) and B.A. Dospekhov (1979).

585. Research was carried out at the territory of experimental site Karsang of Faizabad district with released local variety. Variety of intensive type, mid-ripen, moderate resistant to lodging, relatively winter proof. Height is not so high (70.3-89.2 cm), straw is resistant to lodging. Field experiment was carried out according to the following scheme

Table 92. Experimental scheme of the variations according to the calibration of nitrogen fertilizers application in rainfed site Karsang of Faizabad district

Variations	Rate N kg ha ⁻¹	Application rates of nitrogen fertilizers			
		1- application 50% (at planting)		2 – application 50% (tillering stage)	
1	0	0	0	0	0
2	30	15	113,4	15	113,4
3	60	30	226,8	30	226,8
4	90	45	340,2	45	340,2
5	120	60	453,6	60	453,6
6	150	75	567,0	75	567,0

586. Total area of experimental site is 798 m², 4 replications, 24 variations, length of plot is 7 m, width of plots is 3.6 m, total area of plots is 25.2 m². The following rates of nitrogen fertilizers (ammonium nitrate 34%) were used in rainfed zone: 0;30;60;90;120;150 kg ha⁻¹; According to the experimental scheme we took the site enriched by nitrogen (250 kg ha⁻¹), with 7 m length, 3.6 m width and also farm site with 25.2 m of plot's total area for comparing the data.

587. The first N rate (ammonium nitrate 34%) 50% was applied at planting on 28 October 2008, stage (F-1), second rate of nitrogen 50% was applied at the moment of three leaves and stem appearing on 30 March 2009, tillering stage (F-3) according to the experimental scheme.

588. Measurements by Greenseeker for NDVI determination were started on 18 March 2009 and in every 10-12 days till the end of vegetation. Measurement were done in each plot for 4 times in each replications and also at the farmer's site and at the site enriched by nitrogen (250 kg ha⁻¹).

589. The second measurement was carried out at the moment of 3 leaves and stem appearing (F-3) on 30.03. 2009. The third measurement was carried out during tillering stage (five leaves appearing and development of main and side stems) on 14.04.2009. The fourth measurement was carried out on during booting stage (formation of leaf sheath and appearing of first node on 23.04.2009. The fifth measurement was carried out on 04.05.09 during booting stage (appearing of 2nd node and flag leaf). The sixth measurement was carried out on 15.05.09 during booting stage (appearing of flag leaf's ear). The seventh measurement was carried out on 25.05.2009 during earring stage (appearing of first spike). The eighth measurement was carried out on 02.06.09 during flowering stage (starting of flowering). As a result of strong wind and

continuous rainfalls in March, April and May wheat lodging was observed in some places in the variations with nitrogen application at the rates of 150 kg ha⁻¹, 200 kg ha⁻¹ and 250 kg ha⁻¹. The ninth measurement was carried out on 12.06.09 during milky ripeness stage (ripe grain). The tenth measurement was carried out on 02.07.09 during waxy ripeness stage.

4.9.3.1 Study site

590. Investigations were carried out at the beginning of October 2008-2009 at the eroded brown carbonate soils of Fayzabad experimental site “Karsang”, which is located in the foothills zone of supplied boghara, at the height of 1300-1350 m above sea level, where surface erosion was widely spread. In spite of sufficient amount of rainfalls experimental site is in bad conditions due to active wind regime which dries the soil cover.

4.9.3.2 Soils

591. Soils of experimental site are mountain brown carbonate, mainly highly eroded, heavy loamy with low permeability. Zone of mountain soils constitutes the territory at the height from 1200 to 2700 m and characterized by considerable diversity of natural conditions.

592. Two zones are clearly singled out here:

Brown carbonate 2) brown typical soils (V.Ya. Kuteminskiy, R.S. Leontieva, 1966), which differ from each other not only by climate and planting, but by geo morphological structure as well. Zone of brown carbonate soils covers its down part - huge hilly foothills with thick loess and loess-like loams. Zone of brown typical soils has strongly partitioned and rocky slopes or ridges at the upper part. Our Research were carried out in the zone of rainfed and irrigated agriculture of brown carbonate soils. They are spread in low and middle mountains higher than zone of dark sierozems at the height from 800 to 1400 above sea level. In geo morphological relation zone of mountain brown carbonate soils represents high adyrs of accumulative origin, composed by loess depositions (M.R. Yakutilov, 1963).

593. Zone of mountain brown carbonate soils is characterized by moderate warm climate. Morphological description of one of the pits with mountain brown carbonate soils of “Karsang” site of Faizabad district.

594. A soil profile was done at the leveled water divided grounds in wheat plantings at the rainfed site after harvesting. Pit was bored at the leveled area in southern-eastern part of the site in 250 m from highway.

Soil profile №1

0 ---23 cm brown color, middle loamy, not packed, dry, many carbonates as meadow brown, many roots and small roots of plants, traces of earth digging insects are visible, gradual transition.

23---47 cm brown color many carbonates as pebbles, middle loamy, dry, not packed, many roots and plants' roots, traces of earth digging insects are visible, gradual transition.

47---85 cm brown color, middle loamy, carbonates as white-eye and pebbles, less packed layer, roots of different size, structureless, gradual transition.

85---118 cm brow color, many carbonates as white-eye and pebbles, middle loamy, not packed, dry, roots of plants, structureless, gradual transition.

118---156 cm brown, many carbonates as white-eye and pebbles, middle loamy, not packed, dry, root of plants are visible, structureless, gradual transition.

156---200 cm, brown, many carbonates as white-eye and pebbles, middle loamy, not packed, dry, root of plants are visible, structureless, gradual transition.

Table 93. Content of gross and mobile forms of nutrient elements in the soil.

Place of taking and characteristics of the sample	Depth, cm	Humus, %	mg kg ⁻¹		mg kg ⁻¹ , P	mg/100 g, K
			NO ₃	NH ₄		
Cutting -1 Fayzabad district, mountain brown carbonate soils	0-23	1.19	20.0	6.0	24.0	268
	23-47	0.84	18.0	5.4	11.5	180
	47-85	0.82	10.8	3.24	11.5	180
	85-118	0.80	10.8	3.24	11.5	156
	118-156	0.54	9.8	2.94	7.0	160
	156-200	0.90	7.8	2.34	4.0	156

595. While considering agro chemical properties of brown carbonate soils it can be pointed out that they are poor not only of humus but also of nutrients content both of gross and mobile forms.

596. As can be seen from the Table 93 humus content in plough layer is made 1.19% and in sub plough layer - 0.84%. Downwards to the profile its amount gradually reduces and at one meter depth is made 0.54%. From data analysis can be seen that humus content in these soils is very poor. Content of mobile forms of nitrogen in upper layers consists of nitrate 20.0 mg kg⁻¹ and changes in the layers to 7.8 mg kg⁻¹, and according to the ammonium forms from 6.0 mg kg⁻¹ to 2.34 mg kg⁻¹ in lower layers. Content of mobile phosphate is low, in a metric layer in average from 24.0 mg kg⁻¹ to 7.0 mg kg⁻¹ of soils. 268 mg/100 g of mobile calcium is

contained at the top layer and reduce along the layer to 160 mg/100 g. From given data is clear that soils of experimental site differ by low natural fertility.

4.9.3.3 Climate

597. Climate of Tajikistan is characterized by daily and seasonable fluctuation of temperature, intensive solar radiation, air dryness and small cloudiness. The main climate factors are relatively low latitude, remoteness from the oceans and complicated orography. Zone climate of mountain brown soils with soft winter and warm dry summer can be considered as moderate. Climatic conditions of the zone are favorable not only for grain and grain legumes cultivation but also for cultivation of rainfed vine, fig and pomegranate.

598. Average annual air temperature in the district is made 140 in the southern part and 7.80 in the eastern. Absolute maximum of air temperature is observed at the end of June 38-390, minimum is in January -9.6. Winter is short and quite soft, but sometimes with frost of -200. Average height of snow cover is made 16-23 cm, maximum - 35 cm.

599. Average perennial amount of rainfalls is 840-870 mm, with fluctuation by years from 385 to 1300 mm, which take place mainly in winter-spring period as snow and more frequently as rains of small intensity (0.01-0.1 mm/min). But in spring (April-May) take place intensive heavy rains (0.5-1.0 mm/min).

600. The main amount of rainfalls is observed in spring 307.9 mm (April), the lowest of 1.2 mm in autumn (September). 840-900 mm of rainfalls falls per year.

Table 94. General climatic conditions of Faizabad district (2008-2009).

Name of weather station	Climate	Months									Per year
		IX	X	XI	XII	I	II	III	IV	V	
Faizabad weather station	Air temperature, C ⁰ , ab. max	3.1	10.0	17.4	17.4	11.6	9.6	19.1	24.6	28	
	ab. min	1.3	4.4	-3.6	-7.0	-9.0	-7.5	0.0	0.3	6.	
	Rainfalls, mm	1.2	3.0	54.8	32.4	40.7	156.3	113.4	307.9	168	878.3

601. Foothills - low-mounted district is the spread zone of one-year ephemeral and perennial ephemeral herbaceous vegetation (Goncharov, 1973). Plantings are usually used for grazing. District is also characterized as a spreading zone of tree and shrub's vegetation. In fact forest and shrubs are made only 5% of area. They are represented by broad-leaved maple-nut trees and archevniks.

602. Winter wheat is the plant of warm and moderate climate. Relation of this crop to the thermic factor is defined by low limit of environment temperature, at which growing processes starts and by total heat quantity needed for completing the stage of plant development. Temperature is also one of the main factors at germination stage.

4.9.4 Results and discussion

4.9.4.1 Phenological observations

603. Main results of phenological observations for 2008-2009.

1) Planting – 28 October 2009, 2) Germination – 8 November 2009, 3) Tillering – 31 Marc 2008, 4) Booting – 11 April 2009, 5) Earring – 02 May 2009, 6) Flowering – 12 May 2009, 7) Milky ripeness - 24 May 2009, 8) Waxy ripeness – 05 June 2009, 9) Complete ripeness- 28 June 2009.

604. Climatic conditions of this year made a great effect on the main stages of wheat development. Big amount of rainfalls, relatively low temperature and other negative factors extended the vegetation period to 244-246 days.

605. According to the data from Table 96 various rates of nitrogen fertilizers differently impact on the structure of wheat yield. At raising the rate of nitrogen fertilizers, height of plants in all variations increases from 70.3 cm to 89.2 cm and weight of 1000 seeds increases from 39 to 40.4 g.

Table 95. Effect of nitrogen fertilizers on the structure of wheat yield (2008-2009).

Variations	Rate N kg ha ⁻¹	Height of plants, cm	Length of spike, cm	Productivity of tilling capacity	Weight of 1000 seeds, g
1	0	70.3	7.1	2.5	38.6
2	30	77.1	7.2	2.3	39.8
3	60	76.5	8.0	2.0	40.2
4	90	79.4	7.9	2.0	40.1
5	120	82.1	8.1	2.4	40.3
6	150	80.4	8.3	2.6	39.9
1	0	68.4	7.0	2.2	38.3
2	30	74.0	7.2	2.6	39.5
3	60	75.5	7.1	2.8	40.2
4	90	77.8	7.6	2.9	40.0
5	120	79.8	7.9	2.7	40.4
6	150	85.4	8.0	2.9	40.3
1	0	73.4	7.6	2.4	38.1
2	30	82.3	7.7	2.3	38.2
3	60	86.5	7.5	2.6	39.1
4	90	84.0	8.1	2.6	40.2
5	120	86.3	8.3	2.7	40.4
6	150	85.5	8.3	2.9	40.4
1	0	74.4	7.4	2.2	38.1
2	30	83.5	7.6	2.5	39.1
3	60	85.3	7.5	2.5	38.5
4	90	88.4	7.9	2.9	40.2
5	120	88.6	8.2	2.8	40.3
6	150	89.2	8.4	2.9	40.4

Table 96. Effect of nitrogen rates on the productivity of wheat grain, centner ha-1. Experimental site Karsang, rainfed (2008-2009)

Experimental variation	Rates of nitrogen fertilizers	Replications				Enriched N ₁₅₀ kg ha ⁻¹	Farm site
		I	II	III	IV		
1	0	18.4	17.5	18.5	17.6	26.4	24.2
2	30	21.0	20.5	21.1	20.6		
3	60	23.3	23.5	23.6	23.9		
4	90	25.4	25.2	25.0	25.8		
5	120	26.6	26.5	26.4	26.6		
6	150	27.5	27.2	27.4	27.6		

606. Different rates of nitrogen fertilizers have a very good effect on the wheat productivity. Thus, wheat productivity has increased when the rate of nitrogen fertilizers (ammonium nitrate 34%) was raised in all variations. In control variation it has been made from 17.5 to 18.5 centner ha^{-1} , and in the variations of raised nitrogen rate (150 kg ha^{-1}) from 27.2 to 27.6 centner ha^{-1} . The highest yield was obtained in the variation 6, where it has been made 27.6 c. This means that no need to raise the rate of nitrogen fertilizers in future as the difference between productivity in these variations is not so big. At the site with enriched nitrogen we have obtained 26.4 centner ha^{-1} as in the variation 6 from each replication, and at the farmer's site where 50 kg ha^{-1} was applied, yield has been made 24.2 centner ha^{-1} .

4.9.5 General conclusions for 2009

607. Application of 250 kg ha^{-1} is optimal and reasonable at wheat planting on middle loamy brown carbonate rainfed soils of Faizabad district. High wheat yield of 27.6 centner ha^{-1} was obtained at application of 150 kg ha^{-1} but coming out from economical point of view the effective was variation 5 where we applied 120 kg ha^{-1} and obtained 26.6 centner ha^{-1} where difference between productivity is not so big.

608. At the farmer's site only 50 kg ha^{-1} was applied and yield was very low 24.2 centner ha^{-1} .



Figure 73. Coordinates' determination of rainfed experimental site Karsang.



Figure 74. Measurement by Greenseeker at the experimental site Karsang. Tillering stage (F-3), boghara.



Figure 75. Morphological description and taking the soil samples from soil cutting of experimental site Karsang.



Figure 76. Measurement by Greenseeker, experimental site Karsang, stage of milky ripeness.



Figure 77. Wheat harvesting at the rainfed experimental site Karsang of Faizabad district.

4.10 Tajikistan: Activity 6. Promote community nursery-raising for plantation in sloping lands (Site of Faizabad district).

4.10.1 Introduction

4.10.2 Objectives

609. The main purpose of this work is to work out the methodology of cultivating transplants and fruit, shrubs and other crops by container method from the seeds during winter-spring periods in greenhouses. And their replanting to the open soil for productive usage of slope ravine lands and protecting the ravines from further degradation.

4.10.3 Materials and Methods / Results

610. In 2008 more than 10 thousand of different crops were prepared by container method (Spanish broom, cercis, wild cherry, pine and other crops) for planting at the slope lands and for ravine and slope lands fixation.

611. Transplant were grown in the containers till 10 and more cm height, after that in spring they were planted to the open soil for growing up to the optimal size (70-80 cm). Transplants were grown in the open soils till autumn, and then in autumn or spring they would be replanted to the slope and ravine lands for fighting against erosion in the zone of brown carbonate soils. Table 6.1 contains data of transplants quantity which is still remains. Besides container method of cultivation, big amount of transplants were prepared by vineyard cutting (more than 1000 pieces).

612. Due to the dry climate and small amount of rainfalls in 2008 irrigation water rate sharply reduced that is why majority of springs which had been providing the mountain regions with irrigation water dried. Due to the shortage of irrigation water all vine transplants died and considerable part of transplants replanted to the open soil dried.

613. At present time quantity of alive transplants is 8528 pieces. More than 3000 pieces of different crops are cultivated in containers and in spring 2009 they will be replanted to the open soil for growing till optimal size.

Table 97. Transplants quantity planted to the open soil, 20008.

№	Name of crops	Quantity of transplants, pc.	Dried,%	Alive,%	Quantity of alive transplants, pc
1	Poplar	1000	70	30	300
2	Apple-tree	1300	30	70	970
3	Pine-tree	2000	30	70	1400
4	Vineyard	1500	30	70	1050
5	Spanish broom	3000	25	75	2400
6	Cercis	2500	30	70	1750
7	Cherry	1000	35	65	650
8	Vineyard cuttings	10000	100	-	-
9	Total	22300			8520

Table 98. Types and amount of plantings in the nursery

№	Name of crops	Quantity of transplants, pc.	Dried, %	Alive, %	Quantity of alive transplants, pc. шт.
1	Apple -tree	1500	100	-	1500
2	Thuja	1200	90	10	1060
3	Queen-apple	76	0	-	76
4	Vineyard	400	0	-	400
5	Total	3176			3036

614. Governmental decree about “Greening the territory” was adopted in the Republic of Tadjikistan, for this reason Institute of soil science TACHN actively participated in this important activity related to the improvement of ecological conditions.

615. In this relation in spring 2009 the following planting materials were given free of charge by the request of district’s head for territory greening.

1. Pine-tree - 500 pieces.
2. Spanish broom - 5000 pieces.

616. The following planting materials were given to the farmers free of charge:

1. Cherry - 1000 pieces.
2. Pine - 500 pieces.
3. Spanish broom - 500 pieces.

617. The following transplants were planted at Faizabad experimental site:

1. Dried apricot - 50 pieces.
2. Almond - 50 pieces.

3. Pine-tree - 200 piece.
 4. Walnut - 50 pieces.
 5. Vine - 600 pieces.
618. At present time the following transplants are cultivated at the experimental site:
1. Pine-tree - 1000 pieces.
 2. Vine (cuttings) – 5000 pieces.
 3. Apple-tree - 500 pieces.
 4. Apricot-tree - 100 pieces.
 5. Walnut - 500 pieces.
 6. Crab cherry - 60 pieces.
 7. Wild cherry - 200 pieces.

Total: 9160 pieces

4.10.4 Conclusion

619. Implementation of phyto-reclamation activities helped to fix the ravines and improve grass canopy. Thank to this soil formation processes changed and humus and nutrient content increased almost in two times.



Figure 78. Uprooting the transplants of pine-tree and taking from the nursery for planting at the open site.



Figure 79. Planting of pine-tree transplants for greening and improving ecological conditions in Fayzabad city



Figure 80. Farmers and locals actively participated in activities for greening and improving ecological conditions.



Figure 81. Transplants in the nursery before uprooting.

4.11 Tajikistan: Activity 7. Dissemination of results and developing mechanisms for up scaling and scaling out the SLMR options

4.11.1 Introduction

4.11.2 Objectives

- 4 workshops cum traveling seminars will be organized by the national teams at each site during the years to disseminate SLMR options and to sensitize policy makers and all stakeholders. SLMR options will be shared using mechanisms such as Farmer's Fairs, Field Days, Farmers' Schools etc
- Mechanisms will be evolved for wider community involvement, public awareness and advocacy campaign. Efforts will be made for mainstreaming of the SLM results into national program/ activities.
- At least 3 Dialogues organized on the national TV / Radio networks by the national team on the SLMR options.

4.11.3 Results and discussion

620. On 6 April 2008 seminar was held in cooperation with the head of Faizabad districts at Karsang base station. Heads of Faizabad district with the local governor ("khukumat") chairman and his deputy participated in the seminar. More than 30 heads of farmer and dehqan's farms of Faizabad district were invited for the seminar.

621. Employees of Soil Science Institute with the head of deputy director R.K. Kurbanov, head of soil erosion department R.S. Kabilov, senior scientific officer D. Mirzoboev, postgraduate Kh. Safarov and head of base station A. Boev presented all implemented scientific - research activities for soil protection against erosion, issues of water saving by mulching and line planting, container nursery for transplants growing at the slope lands, protection of ravine lands by planting various shrubs, construction of gabion structures for rehabilitation and fixation of the lands affected by ravine erosion.

622. Besides that according to the research results in 2008 were organized: 1 - photo exhibition, 2 - meeting with farmers in Vakhsh filial of Agriculture Institute, 3- Speech in TV-1, 4- speech in Republican radio.

623. In 2009 in state language were published: 4 brochures, one of them was published by Vakhsh filial, 1 farmer day and 1 training for Indian planter were carried out in Vakhsh filial, 1 farmer day was spent in Fakhraabad district by Soil science Institute.

624. In June 2009 at the experimental site Karsan of Faizabad district scientific-practical zone conference was held on the topic “Methods for fighting against erosion: where 60 people participated from 8 districts, representatives of agriculture management, vodkhoz and farms.

625. Six representatives from Institute made presentations for the topics of soil protection from erosion, preservation of soil moisture and ways of increasing the productivity of rainfed lands.

626. Conference was played in the first channel of state television in the program “Akhbor” as well as special reportage about scientific achievements in fighting against soils erosion, carried out with international center ICARDA.

627. Necessary photos and video materials were collected, copies of which were presented to the main office of ICARDA in Tashkent.



Figure 82. Opening of zone conference in Faizabad district.



Figure 83. Course of conference



Figure 84. Speech of Institute's staff



Figure 85. Head of soil erosion department R.S. Kabilov explains the role of mulch in preserving the soil moisture and organic matters increasing in the soil

4.12 Tajikistan: Activity 8. Crop production on irrigated saline soils in the Vakhsh valley

4.12.1 Introduction

628. Tajikistan is an agrarian country and its future inseparably connected to the development of agricultural branches. Since olden times bread value and its production takes a special place in comparison with other crops. According to the economists' calculations 1.5-1.6 million tons of grains should be prepared in order to supply population and other economy branches of republic. Production of such grain quantity requires implementation of a number of activities.

629. The following factors can promote the productivity increasing taking into account bioclimatic potential of the zones in the republic and introduction of scientific research's results:

1. Strict observance of cultivation technology and correct selection of arable lands, in particular irrigation lands. Together with this real productivity increasing is possible in 1.5-2 times.
2. Scientifically explained selection of crops' types and varieties taking into account regional peculiarities, rational usage of high quality seeds and introduction of intensive techniques for grain crops cultivation.
3. Effective usage of existing economical-technical resources, timely application of optimal rates of organic and mineral fertilizers, crops' protection from diseases and pests, drastic introduction of science achievements and advanced practice.
4. Trying to obtain two grain yields per year from irrigated lands with a help of existing bioclimatic resources (sufficiency of water, warm, duration of vegetation period).

630. Cotton growing is the main agricultural branch of the Republic of Tajikistan and its development is very important for our country. There had been times when total volume of cotton production reached one million tons. Thus, for the last years production of raw cotton sharply dropped. Total yield volume reduces from 447.9 thous. ton to 557.0 thous. ton. The main reasons are the lack of general turnover means, inobservance of traditional crops' cultivation and material incentives of deqhkans.

4.12.2 Research need

631. Works planned by the program were carried out in Vakhsh valley of Tajikistan.

632. The main reason of soil salinity in Vakhsh valley is close ground water occurrence. Salinity processes are not so developing if the depth of Groundwater is deep (more then 3 meters). If the level of Groundwater is less then 3 meters then mineralization increases and the process of soil salinity in spite of flaking effect from irrigation water begins to prevail. Soils

become poor saline, mostly accumulating soluble salts. Further rising of Groundwater' level or their mineralization increasing causes more intensive salinity development.

633. Productivity of agricultural crops at poor saline soils is quite low. Main point of poor saline soils reclamation is in dilution of soil solution to the concentration not harmful for the plants. These dilution is carried out by several methods:

1. By the methods of winter or spring leaching with small rates along the grassland fire and furrows;
2. By appropriate regimes of vegetation irrigation.

634. A great importance in further improvement of agriculture, increasing of yield, gross production of cotton and other crops had the prevention and fighting against lands salinity and logging. Not carrying out reclamation activities at the irrigated lands with not enough groundwater outflow leads to groundwater balance worsening, promotes their gradual raising and soil salinity development. It is obvious that some part of the lands with normal, non saline soils can be salted, at other lands salinity can be strengthen to such extent that it would not be possible to use them in agricultural rotation. That is why in all farms and districts where reclamation conditions of lands can be worsen due to the natural factors, measures should be taken for prevention and fighting against salinity and logging of the lands.

635. Main tasks of preventive activities are:

- a) do not accept the water losses which cause the groundwater's raising;
- b) to reduce moisture evaporation from the soil;
- c) to reduce a high level of groundwater occurrence.

636. For these reasons problem of soil salinity in all farms and fighting against it is very actual in Tajikistan. Solution of this problem is one of the main and effective ways for increasing the productivity of all agricultural crops.

4.12.3 Objectives

637. The main purpose of implemented Research is to monitor separate indicators of reclamation condition "Soil salinity" at key selected sites. Tasks of Research include:

- investigation of grain crops' productivity: wheat, barley, rape and shabdara in low saline soils.
- investigation of productivity of sorghum, millet and licorice in low saline soils.
- investigation of thin fiber cotton productivity in leaching low saline soils.
- cotton cultivation with mug bean at 60 cm raised-beds.

- Characteristics assessment of best varieties of wheat, barley, rape and shabdara in conditions of not so deep level of mineralized Groundwater.

4.12.4 Materials and Methods

638. Research methodology includes the regular measurements of given parameters at key sites. Research were carried out in field and laboratory conditions. Soil salinity, mineralization of ground, collector, drainage and irrigation waters at the selected site will be determined in field conditions.

639. Periodicity of monitoring observations over;

- conditions of soil salinity 2 times (spring and autumn periods)
- salinity of groundwater, collector, drainage and irrigation waters, monthly during vegetation period.
- condition of water salinity in collector-drainage network at the key sites.

640. Laboratory Research include the implementation of chemical analyses of soil, ground, collector, drainage and irrigation waters. Methodology of analyses is conventional for Central Asian regions.

4.12.4.1 Study site

641. Vakhsh valley is situated in subtropical dry zone, which in climatic relation looks like dry irrigated regions of Africa, Egypt, America (south-western states of USA) and some regions of India.

642. All soils of Vakhsh valley by the character of soil formation processes are laid in three main genetic types:

1. Sierozem.
2. Alkali soil.
3. Paludal soil.

643. Sierozem type is zonal. Sierozems take the last place among prairie soils, which develop under prairie plants under the influence of rainfalls without groundwater's participation.

644. Subject of research was low saline soils of agriculture Institute's filial which located in Bokhtar district of Khatlon province.

645. Soil of experimental site is old irrigated light sierozem. Sierozem- meadow and meadow- marsh soils are also met in the zone. Mechanical composition consists of sandy-loamy, loamy to clay loamy and heavy clay soils. Relief is of pit form. Humus content is from 0.53 to 0.75%, nitrogen is from 0.52 to 0.66%, calcium is from 1.0 to 1.7% and phosphorous is from 0.124 to 0.150%. Soils of Vakhsh valley mainly consists of non saline, low and moderate saline soils. Process of repeated salinity is observed in these soils. Irrigated lands of this region mainly

are located at the heights from 300 to 900 m above sea level. Old irrigated soils of the third and in some places of the second part of terraces were formed in conditions of constant accumulation of fresh river drifts under the crops' plants.

4.12.4.2 Climate

646. Kurgan - Tyube zone of Vakhsh valley is situated in south-western Tadjikistan and constitutes the whole territory till the republican borders to the raised-beds of mountains Sarsaryak and Terekli Tau in the east. Climate of the zone differs by hot dry summer, not long (55-65 days) warm winter with broken weather and small amount (150-300 mm) of annual rainfalls. Duration of warm period in the valleys of the province is made 250-300 days, the period with air temperature more than +10°C for this period is made 4500-58000, and effective temperature is made 2600-30000. Sunshine duration is made 2700-2800 hours per year.

4.12.5 Experiment 1: Crop varieties.

647. The following crop varieties were tested in the field:

- wheat "Navruz"
- wheat "Atay-85"
- wheat "Djager"
- barley "Marokko 9/75"
- barley "Chenad-345"
- rape
- shabdar

648. No further data and results were provided.

4.12.5.1 Conclusions

649. In conditions of moderate salinity with close Groundwater occurrence where cultivation of cotton and maize is not possible, grain crops as wheat of "Navruz" variety, barley of "Chenad-345" variety can be cultivated in which grain productivity is 25.6-28.6 centner ha⁻¹ respectively.

650. Besides that intermediate crops as rape and shabdar can be cultivated in these soils. Green mass productivity of these crops reaches 300-350 centner ha⁻¹, seed productivity of rape is 2.7 centner ha⁻¹ and of shabdar is 3.6 centner ha⁻¹.



Figure 86. Planting of grain and cereal crops in Vakhsh filial of the Institute of Agriculture.



Figure 87. Seminar on the usage of grain and cereal crops on low saline soils of Vakhsh filial

4.12.6 Experiment 2: Usage of salt resistant crops in saline soils.

651. Halophytes are the most effective for radical improvement of reclamative lands' condition. Method of halophyte application will be considered for low saline lands rehabilitation in conditions of not deep and mineralized ground water occurrence.

4.12.6.1 Experimental crops: Millet and sorghum

652. The following crops were planted in this field experiment carried out on 28.04.2009:

Millet

653. Millet. (*Panicum miliaceum*) is one of the most salt resistant grain crops. American authors paid attention on a millet's high salt resistance, who thought that millet can grow in the soil with salt content till 0.6-0.8%. High salt resistance of millet can be explained by crop antiquity in the south-eastern Europe where saline soils are widely spread. Millet gives essential yields at the saline soils in case of two vegetation irrigation. Good millet development in irrigated conditions is explained by surface root system at the top layer which is under the influence of irrigations evidently leached. At similarly saline soils wheat suffered more than millet because its roots reach more deep and saline layers.

Sorghum

654. Sorghum (*Andropogon sorgum*) - is one of the most salt resistant grain crops. High salt resistance of sorghum was noted by D.N. Pryanishnikov and I.V. Yakushkin who considered sorghum as one of the most salt resistant plant. Strong development of root system stipulates the sorghum to grow on such soils (for examples, solonetz), which are almost not suitable for cultivation of other grain crops.

4.12.6.2 Conclusions

655. It was determined that in moderate saline soils with close ground water occurrence it is successful to cultivate millet crops which grow quite well and give nice productivity at about 8-10 centner ha⁻¹ of grain.



Figure 88. Crops' selection for planting on the moderate saline soils

4.12.7 Experiment 3: Effect of two water treatments on thin-fibered cotton (variety 93260-B) productivity

4.12.7.1 Cotton

656. Cotton (*Gossypium hirsutum*) - is the main crop at the irrigated fields of the republic. That is why cotton is more subjected to the soil salinity than other crops. In comparison with other crops cotton is considered as quite salt resistant crop which can tolerate high salt content in the soil. Maximum salt content at the top soil layer at which cotton cultivation is acceptable is made 0.5 % of salt.

657. In relation to the salinity cotton is considered as contradictory crops - at low salinity cotton yield reduces but at the same time can tolerate a very high salinity of 0.8%; this cotton ability in considerable extent depends on soil mechanical composition, climate conditions, illumination degree. At saline site cotton germination delays for 10-15 days in comparison with non saline site.

658. Young growth of cotton at the saline soils is delayed together with simultaneous reduction of seeds germination. Reason of germination reduction and low cotton seeds growing at the saline sites is their slow swelling in saline soil solutions.

659. High cotton sensitivity to the salinity in the period of germination is explained by the lack of osmotic active for water consumption from the saline soils. Grown-up cotton shrubs thank to suction power of root cells and leaves transpiration have the chance to take necessary water minimum for their vital functions. Varieties of thin fibered cotton are more tolerant then middle fibered cotton.

660. Cotton young growths at salinity are in depressed condition, they are behind the growth and development and the growing of new organs delays for several days in comparison with the plants of non saline background.

661. Depression of growing processes at the saline soils lasts also at the last vegetation stages. Cotton is still behind the growth, develops slowly and forms very few branches and generative organs.

662. Under the influence of soil salinity height of first sympodial branch increases that is probably connected to a delay of generative development; number of monopodial and sympodial branches reduces as well as amount of fruit elements, growing processes are delayed as a result of which plants do not grow high and their internodes are short with thin stems, cotton has the character of late-ripened variety.

663. At low moderate soils when root system reaches the non saline layers, depression signs of cotton to some extent disappear. Cotton development period at saline soils lengthens due to the time prolongation from young growth to budding stage. Especially delays the growing of

consecutive nodes and due to this fruit formation starts late and characterizes cotton as late-ripened variety.

664. Young cotton growths were cut in the variation without leaching. Together with this due to the difference and degree of soil salinity, germination density in various place of the same site is not equal. For this reason crops' heterogeneity was created in the growth and development of the plants.

665. Not only growth but also development of plants was delayed (passing of their reproductive stages). Thus, in the variations without leaching cotton development stages in comparison with variation with leaching delayed for 17 or more days.

666. Agro techniques in the experiment is simple, accepted in given farm: annual under-winter plowing at the end of November - at the beginning of December to 30-35 cm depth; reserve irrigations - end of March - beginning of April at a rate of 1.5-2.0 m³ ha⁻¹. Planting of 9326-B variety was done on 2 April 2008 and on 25 April 2009. Mineral fertilizers were applied at the annual rate of 200 kg ha⁻¹ nitrogen and 150 kg ha⁻¹ phosphorous.

4.12.7.2 Experimental treatments

667. The productivity of cotton was assessed for the following leaching treatments:

1. Without leaching.
2. After leaching.

668. Phenological observations were made at the cotton growth stages: planting germination, budding, and flowering.

4.12.7.3 Results

Cotton growth and development 2008

1. Without leaching 2.IV 28.V 68.7 17.06 22.07
2. After leaching 2.IV 17.V 77.0 3.06 8.07

Cotton growth and development 2009

1. Without leaching 25.IV 17.V 75.7 2.06 5.07
2. After leaching 25.IV 12.V 86.4 25.06 1.07

4.12.7.4 Discussion

669. Correct reclamative preparation and lands irrigation are very important in the system of agro technical activities, which provide the usage of saline land. At irrigating the cotton at saline and subjected to salinity lands it is necessary to take into account the salinity degree of these lands as well as degree of their drainage.

670. At not enough leached lands, with saline ground water occurrence and absence of well drainage and at the time of strong seasonal salinity, irrigation regime should be determined for reducing the salinity damages and for creation the conditions for normal plants' development during vegetations and for obtaining high yields. These can be achieved by more frequent irrigation of less rates and total amount of irrigation should be increased in two-three times in comparison with non saline soils.

671. Mentioned techniques promote the dilution of soil solution and concentration reducing harmful salts in this solution that would provide better water feeding of plants.

672. For gradual reduction of salt reserves in the soil and for reduction of ground water mineralization, it is recommended in autumn after harvesting to make irrigation along the remained furrows with a rate of 1.5-2.5 thous. m³ ha⁻¹ and then in spring at a rate of 1.5-2.0 thous. m³ ha⁻¹. Such irrigations during 2-3 years will give a chance to transfer low and moderate soils to the category of non saline soils.

673. Drainage network should be cleaned in time and maintained in good working conditions for successful implementation of the whole cycle of reclamative activities.

4.12.7.5 Conclusions

1. It is determined that from moderate saline soils good productivity of thin fibered cotton can be obtained if soil leaching would be done before the planting date. In this case productivity of raw-cotton is made 25-27 centner ha⁻¹ that is for 5-6 centner ha⁻¹ more in comparison with planting without leaching.
2. Productivity of tillering, stem's height, spike's length, amount of spikes and grains in the spike and most important grain yield increases of the plants which have been grown during a number of generations at the saline soil.
4. Salt resistance of agricultural crops considerably depends on historical peculiarities of type and variety formation, possibility of cultivation in the past on saline lands. That is why sometimes the character (type) of soil salinity is vital as the variety salt resistance to one type can be changes in another salinity type. In conditions of different types of soil salinity, specific varieties can be changed in some places according to the degree of salt-tolerance and salt-resistance.
5. The most salt-resistant plants in conditions of predominate chloride and sulphate type of salinity is millet, barley and wheat. Cotton is relatively salt resistant crop but less than barley and millet.



Figure 89. Cotton planting on low saline soils, Vakhsh

4.12.8 Experiment 4: Cotton cultivation with legumes crops.

4.12.8.1 Methods

674. On 01.05.2009 middle fibered cotton VD-11 was planted with mug bean. Plant's density measurements, phenological observations were carried out over cotton and mug bean growth and development.



Figure 90. Cotton and mug bean planting at 60 cm raised-beds.

4.13 Dissemination

- On 16.03.2009 farm's day was held for operating the Indian planter.
- On 20.04.2009 seminar was held with farmers' participation on the theme "To work out the methods of management and widen reproduction of eroded and waste soils' fertility". Recommendations are being prepared for farmers and deqhkans on these themes.
- On 23.05.2009 a farmers' field day was held for operating the Indian planter at maize crops.
- On 22.06.2009 training was held for the cotton and mash plantings.
- On 30.06.2009 recommendations «Технологияи нигоњубини пахта» was published for farmers.
- On 07.07.2009 farm's day was held on operating the Indian planter after wheat harvesting to the second maize planting to the grain along the remained furrows.

4.14 Research needs for future implementation

675. We consider necessary to investigate different types and varieties of cotton, grain and legumes crops in moderate soils with close ground water occurrence.

676. If in the past we investigated one type of cotton (thin fibered) then in future we will study the comparison in planting of two cotton types (thin and middle fibered) on moderate saline soils with close ground water occurrence without and with soil leaching. This will help to find out which cotton type grows better on the low saline soils and will help to provide productivity with and without soil leaching.

677. According to the biological features grain legumes crops are resistant to moderate saline soils. Coming out from this we think necessary to study the growth, development and productivity of grain legumes in particular mug bean and mushung.

678. At the same time we will investigate the efficiency of presented Indian planter for planting the mentioned crops in this farm and in other farms.

4.15 Tajikistan: Activity 9. Soil salinity determination in conservation agricultural systems and farmers' systems using the electro-magnetic method

4.15.1 Objectives

- Reduced salinity in the root zone for improved yields
- Reduced Spatial variability in salinity distribution and plant growth
- Saving in irrigation water
- Improved crop yields and incomes

4.15.2 Materials and Methods

4.15.2.1 Treatments

679. Two agronomic practices were examined:

- Common practices: Spring wheat / Cotton,
- Zero-till planting

680. The same NPK fertilizer doses were applied to both treatments. The amount of irrigation water was applied as needed.

1. Salt Leaching methods

- Shallow Seeding (primed seed) followed by post-sowing (10cm) irrigation (PoSI)
- Pre-sowing irrigation (leaching, 10cm) followed by seeding at usual depth (PSI)

2. Residue Management

- No residue retained
- Residues retained on the surface

681. Additionally, the effect of laser-assisted land leveling was tested. The subsequent field layout of the experiment was as follows:

- Laser	- Laser	- Laser	- Laser
+ PoSI	+ PoSI	+ PSI	+ PSI
-Residues	+Residues	- Residues	+ Residues

4.15.2.2 Data collection

- Salinity measurements in various treatments at 25 days after germination, 50 days and at anthesis stages using EM probe. Pl note that it is absolutely essential that NDVI measurements dates also coincide with the EM probe measurements
- Salinity measurement at maturity
- Irrigation water used in leveled and unleveled fields
- Plant attributes
- Crop Yield in different plots
- Average salinity buildup in soil profile

4.15.3 Results

682. For this activity, no results were provided.

4.16 References (Tajikistan)

Blagoveshenskiy and Kabilov, 1960;

Blagoveshenskiy and Turdiev, 1961;

Simavskiy

5 Turkmeinstan research report

5.1 Turkmen research team

5.1.1 Benchmark site 31 (Bugdaily)

National Coordinator, National Institute of Deserts, Flora and Fauna (NIDFF), Ministry of Nature Protection of Turkmenistan	M. Nepesov
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5.2 Time schedule of research activities in Turkmenistan 2007-2009

Table 99. Time schedule of research activities in Turkmenistan 2007-2009

Turkmenistan	Qr3	Qr4	Qr1	Qr2	Qr3	Qr4	Qr1	Qr2	Indicators	Outcomes
1. Assessment of yield losses due to late planting in cotton-wheat cropping systems		X	X	X	X	X			Reports on yield losses due to salinity and salt tolerance ratings	Neighboring farmers practice the different technologies developed in the project to improve quality of natural resources
2. Assessment of yield losses due to salinity; determine salt tolerance of cotton and wheat under prevailing climatic conditions				X	X	X				
3. Farmer participatory trials for validation, fine-tuning and development of new RCTs				X	X	X	X	X	Methodology for assessment of agronomic management interventions on growth and land quality developed	Farmer begin custom services and SMEs initiate agribusinesses
4. Develop permanent raised-bed planting systems for cotton – wheat rotations				X	X	X	X			
5. Maintaining favorable salt balances in raised-bed systems for cotton-wheat rotations				X	X	X	X		Other reports	
6. Potential of pigeonpea in developing surface cover to control soil erosion in sloping lands			X	X	X	X	X	X		
7. Calibration and use of the Greenseeker for measuring crop development, comparing crop management practices and efficient nitrogen management				X	X	X	X	X	Other reports	
8. Evaluate the impact of laser-assisted land leveling on water savings, salinity and yields in irrigated agro-ecologies			X	X	X	X	X	X		
9. Dissemination of results and developing mechanisms for upscaling and outscaling of the SLMR options				X	X	X	X	X	Other reports	

5.3 Turkmenistan: Activity 1. Assessment of yield losses due to late planting in cotton-wheat system

5.3.1 Introduction

683. Winter wheat and cotton are the dominated crops in agriculture of Turkmenistan. Dates of crops' planting are very important for getting good and even sprouts and high yields of good quality.

684. Unfortunately, in industrial conditions, planting of crops in majority of cases are carried out in a bit different dates from the optimal planting terms. This is mainly connected to an insufficiency of techniques, irrigation water, especially in the places where water supplied by pumps, which frequently break down and also with organization of works, and in specific years with weather conditions. Terms of planting are delayed in rainy years.

685. In relation to mentioned above Research of actual cotton and winter wheat planting were carried out in industrial conditions during 2 years. Cotton planting was carried out at different dates: early - from the middle of March till 10 April; optimal - from 10 till 25 April; late - from 25 April till 10 May and very late - after 10 May.

686. Winter wheat planting was carried out: early - from the end of August till 15 September, optimal - from 15 September till 10 November, late – from 10 till 30 November and very late after 30 November.

5.3.2 Objectives

687. Purpose of this research is to investigate the optimal dates of main crops' planting and evaluate harvesting losses due to early or late planting.

5.3.3 Materials and Methods

688. Chosen farmers planted cotton and winter wheat at different dates (i) early, (ii) in time, (iii) late, (iv) very late (20 cases for each category). They made observations over development stage and over agro technical activities. Also they collected data for cotton and winter wheat yield during current agricultural season. Data for crops' productivity were provided by farmers to the purveying centers. These data are confirmed by official documents presented to farms.

689. Schedule of cotton and winter wheat yield's effect on the planting dates at the site was made according to the presented data. Harvesting losses were determined by comparing data with optimal dates of planting. Use the schedule of appropriate technologies for getting productivity data depending on the planting dates.

5.3.3.1 Study site

690. It should be pointed out that weather conditions in both years were favorable for the growth and development of good yield, amount of effective temperature in 2007 was less than in previous years, and in 2008 was higher than average annual rates. As a result all this reflects on the productivity of cotton and winter wheat.

5.3.4 Results and discussions

5.3.4.1 Experiment for cotton (2007-2008.)

691. Observation results by 1 September are given in the Table 100, when cotton gets maximum of boll elements and when cotton bolls begin to open.

Table 100. Effect of cotton planting dates on growth and development of cotton (average for 2007-2008)

Planting dates	Parameters				
	Plant height, cm	Number of sympodial branches, pieces	Number of bolls, pieces	Plant density, 1000 plants/ha-1	Weight of cotton in 1 boll, g
Early 15.03 – 10.04	92.8	15.5	8.0	79.3	3.9
Optimum 10 – 25.04	97.7	16.1	10.7	91.9	4.0
Late 25.04 – 10.05	86.2	14.9	7.1	83.4	3.8
Very late after 10.05	69.6	12.9	4.8	76.0	3.5

692. From the given data is obvious that better development and good yield collection was observed at cotton planting from 10 till 25 April, i.e. at optimal date Here height of plants has been made 97.7 cm, number of sympodial branches - 16.1, bolls in one bush - 10.7 pieces. At other planting dates this rates are reduced. For example, at very late planting after 10 May these rates have been made relatively 69.6 cm, 12.9 and 4.8 pieces. Cotton density at optimal planting dates has been made 91.9 thousand of plants in one hectare. At other terms it was less - 79.3 – 83.4 thousand of plants. The same rate was noted in cotton mass of one boll. If cotton was planted after 10 May and mass has been made 3.5 g then at optimal date it was equal to 4.0 g, i.e. for 0.5 g more. Table 101 contains the data of raw cotton productivity at the different planting dates. Yields obtained from 20 farmers were counted at each planting date. Average yields are given in the Table and yields obtained by each farmer are given in the Attachments.

Table 101. Effect of cotton planting dates on cotton yield (average for 2008-2009)

Planting dates	Area, ha	Gross yield, t	Yield, t ha-1	± to optimal date
Early	117.25	280.25	2.39	11.5
Optimum	82.0	290.55	3.54	-
Late	92.45	184.45	2.00	15.4
Very late	112.25	128.5	1.14	24.0

5.3.4.2 Experiment for winter wheat (2008-2009)

693. At planting in early dates full germination appeared after 6-7 days, in the optimal date after 8-10 days, in late dates after 12-15 days and in very late date after 21-25 days.

694. At the early date tillering of “Skifyanka” variety wheat begins in 30-31 days, at the optimal date in 37-38 days, at late date in 42-48 days and at very late date in 59-60 days after germination. At early date booting stage in some places started before winter, and at very late date wheat tillering started only in spring. It should be pointed out that winter 2008 was extremely cold, air temperature lower -15°C stayed for a long time that led to the thinning of wheat planted at early and very late dates as well as to the reduction of productivity. Winter 2009 was warm that stipulated good development and yield of winter wheat. Results of observation and calculation carried out before harvesting are given in the Table 102.

Table 102. Effect of winter wheat planting dates on winter wheat growth, development and yield (average for 2008-2009)

№	Planting dates	Plant attributes					
		Plant height, cm	Plant density, Noha-1	Number of spikes in 1 m ²	Number of grains in 1 spike	Weight of 1000 grains, gr	Yield, t ha-1
1	Early 25.08-15.09	69.8	2.62	316	23	34.5	25.9
2	Optimal 15.09-10.11	92.2	3.28	410	32	31.5	47.7
3	Late 10.11-30.11	78.6	2.82	343	27	35.0	32.9
4	Very late 30.11	55.1	2.23	252	19	31.0	13.5

695. From the given data is obvious that better plant development, the most density, number of spikes, grains in spikes and weight of 1000 grains are observed at optimal date. Here height of plants has been made 92.2 cm, plant density - 3.28 million of plants in hectare, number of spikes in 1m² is 410 pieces, average number of grains in one spike is 30, weight of 1000 grains is 35 g and productivity is 47.7 centner ha⁻¹. At other dates, especially at very late date these rates sharply reduce. This is related to a very cold winter and hot dry spring. Table 102 contains

detailed data of four planting dates, obtained from the sites by 20 farmers. Average yields for each planting dates are given in the Table 103.

Table 103. Effect of winter wheat planting dates on winter wheat yield (average for 2008-2009)

№	Planting dates	Area, ha	Gross yield, t	Yield, t ha ⁻¹	± to optimal date
1	Early	239	618.1	25.9	-21.8
2	Optimal	295.5	1409.0	47.7	-
3	Late	276.9	909.9	32.9	-14.8
4	Very late	196.6	264.7	13.5	-34.2

696. The highest cotton yield of 35.4 centner ha⁻¹ was obtained at the optimal planting date from 10 to 25 April. High yield at this date is explained by the most plant density, one boll weight in raw cotton and collection of big amount of fruit elements.

697. According to the data was formed the effect graph of cotton and wheat productivity on the planting dates which are given in Figure 91, Figure 92, Figure 93, and Figure 94.

5.3.5 Conclusions

698. The highest cotton yield of 35.4 centner ha⁻¹ was at the optimal planting date from 10 to 25 April. Reduction of plant density, bolls number and one boll weight in the raw cotton is observed at early and late planting dates. Reduction of density at the early date takes place due to the low temperatures, high humidity, spread of root rots and at late dates due to the insufficiency of moisture in the upper soil layer because of the fast evaporation under the influence of high temperatures. All these bring to the reduction of cotton productivity. Here harvesting losses in comparison with optimal planting date were made 115-240%.

699. At early winter wheat planting date productivity reduces for 21.8 and at very late date for 34.2 centner ha⁻¹ in comparison with optimal date where 47.7 centner ha⁻¹ was obtained.



Figure 91. Cotton yields under early plantation (2007).



Figure 92. Cotton yields depending on dates of planting (2008).

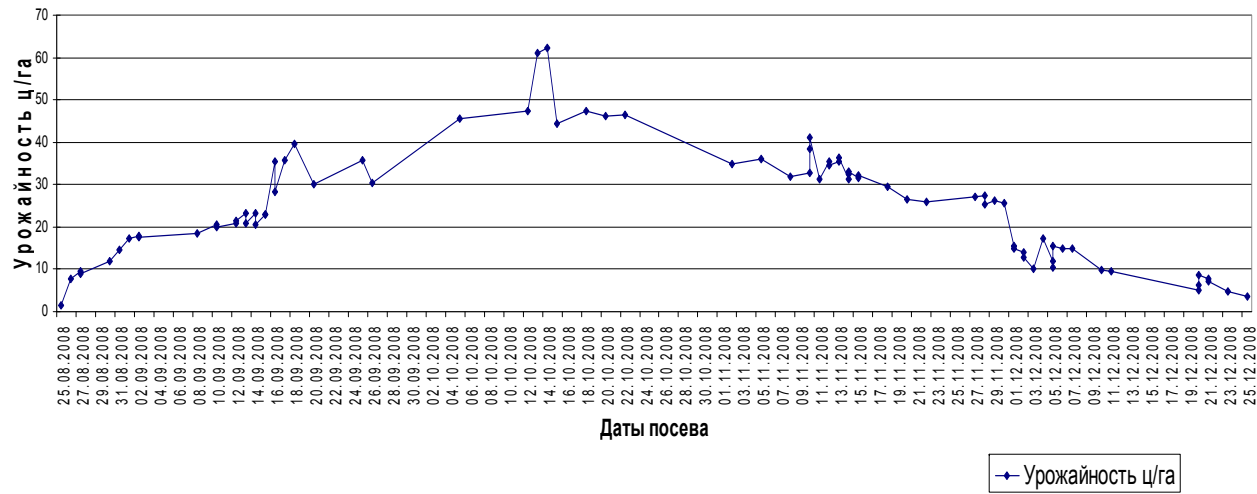


Figure 93. Productivity of winter wheat depending on planting date (2008)

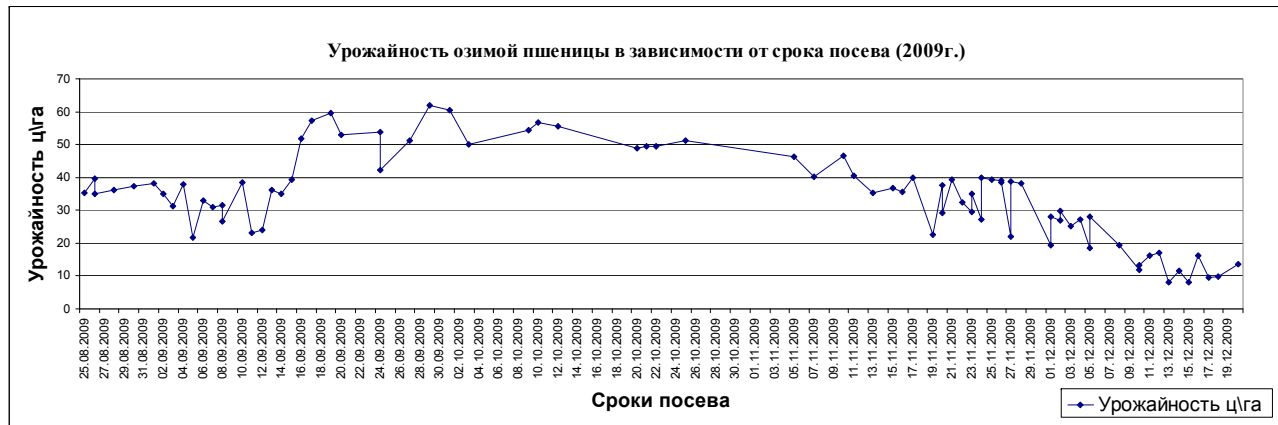


Figure 94. Productivity of winter wheat depending on planting date (2009)

5.4 Turkmenistan: Activity 2. Evaluation of crop losses as result of soil salinity, evaluation of cotton and wheat resistance for saline soils at local soil and climatic conditions

5.4.1 Introduction

700. Area of Turkmenistan lands, appropriate lands for crops' cultivation constitute about 17 million ha. At present time two million hectares are irrigated. Major part of lands in the country has small slopes with high level of Groundwater. Most of them are salted and logged (impounded) lands. In the country more than 68% of irrigated lands have middle and high level of salinity. Reason of this phenomenon is small length and low efficiency of existing drainage systems as well as high water losses from the irrigational systems. At the saline lands productivity of crops reduce to 40-50% in comparison with almost not saline lands.

701. Living standards and incomes of rural population are directly connected to the soil salinity and water logging of irrigated lands. In this relation complex of activities should be worked out aimed to the effective lands' usage, prevention and removal the salinity, logging and impounding in the irrigation agriculture.

702. In order to implement these activities appropriate knowledge is needed for proper usage of irrigation water and for fighting against salinity and logging of irrigation lands.

5.4.2 Objectives

703. The purposes of research are:

- to improve the land usage by working out activities for rational water usage and for fighting with repeated salinity;
- to work out the methods reducing negative soil processes, increasing the productivity of irrigation lands and improvement of rural population's living standards;
- to find connection of soil salinity level with crops' productivity.

5.4.3 Materials and Methods

704. Materials obtained directly from observations at the experiment site (level of Groundwater, soil and water salinity) were determined in the laboratory of Agriculture Institute. At the selected sites "wells" were installed, where system observations were carried out over level changing and ground water mineralization. Soil samples for the salinity were taken from plowing layer by the shovel. Then perforated plastic pipe was driven into this well.

705. The following types of work were determined in accordance with program of scientific-research activity of the Project:

- mechanical composition of soils were defined according to Kachinskiy and browsing method;
- volume weight was determined by the cut-ring method (100 cm³);
- specific weight of soils was determined by the bottle method;
- porosity of soils by calculation according to the formula;
- water-soluble salts (soil salinity) according to the method of SouyuzNIHI
- electric conduction of soils was determined by conductometer;
- agro climatic data were obtained from weather station located in Ashgabat.
- plant density and wheat grain yield measuring were carried out in field and laboratory conditions at the area of 1 m² (in 3 replications);
- cotton and wheat productivity was determined in field and laboratory conditions.
- for observing the ground water level wells were drilled manually. Then perforated plastic pipe was driven into this well.

5.4.3.1 Study site

706. Experiment field where observations were carried out over development of wheat and cotton located at the territory of irrigation district “Parakhat” of dekhkan community “Bugdaily” which is situated in 80 km to the north-east from Ashgabat. Site is under the new development. Irrigation here has begun recently after total land leveling. KDS construction has begun in 2005. Irrigation has begun without construction of hydro technical structures. Irrigation canals up to present time are on the lands’ beds. Mineralization of irrigation water is made till 1 g l⁻¹. Drainage water is directed to the north to Karakum where part of flow is used for the cultivation of fodder, grain and watermelons, and part is discharged to the Transkarakum collector system.

707. Four sites were chosen for experiments of cotton and wheat planting: site with good, middle, bad and very bad plant conditions. Drainage influence on the conditions of cotton and wheat was not so evident because the drainage system was plant-filled and silted. Soils of experimental site are light sierozem, light and moderate loam mechanical texture (alplitite - 20 – 36 %, from them content of silted fraction is 11 – 12 %).

5.4.4 Results and discussions

5.4.4.1 Experiment for winter wheat

708. Wheat planting was carried out only by loosening the upper soil layer by chisel at 13-15 cm depth. Mineral fertilizers (ammonium nitrate, sometimes Urea) were applied and packing was carried out after planting 240 kg ha⁻¹ of wheat seeds (“Yubileyniy” variety in 2007), “Turkmenbashi” variety in 2008). After wheat planting field was irrigated with mineralization

of 1.4 g l-1. Together with this many difficult agro technical techniques for winter wheat cultivation were not used. Agro technical activities implemented at the site under winter wheat are given in the Table 104.

Table 104. Farming practices at the site under winter wheat

Farming practices	Dates	
	2007-2008	2008-2009
Pre-sowing tillage	26.10.2007	15.10.2008
Planting	27.10.2007	16.10.2008
Irrigations: 1 st Post sowing irrigation	29.10.2007	25.10.2008
2 nd Irrigation	12.03.2008	20.03.2009
3 rd Irrigation	21.04.2008	17.04.2009
4 th Irrigation		04.05.2009
Application of Ammonium Nitrate 200 kg ha-1	29.10.2007	20.10.2008
Phosphorous 200kg ha-1 2	11.03.2008	12.03.2009
Manure 5 t ha-1		12.03.2009
Winter wheat harvesting and yield estimation	30.05.2008	14.06.2009

709. Changing of ground water in wheat field in 2007-2008 is given in the Table 105. In 2008-2009 at the huge wheat field (point 1/1; 1/2; 1/3) level of Groundwater varied from 141 to 182 cm with mineralization of 12.2-14.8 g l-1. Water is salted, type is sodium-calcium, according to anionic composition is sulphate-chloride (Table 106).

710. Table 105 contains data reflecting the influence of soil salinity on the growth and development of winter wheat.

711. Soils of first site are high saline. On the raised-bed of furrows soil content reaches 12 % of dense residue, on the slop of furrows – 14 %, at the bottom of furrows – 2.2 %. Wheat hardly survives only at the bottom of furrow where precipitations stay. Productivity of wheat has been made 2.7 - 7.3 centner ha⁻¹.

712. Soils of second site are moderate saline. On the raised-bed of furrows amount of water-soluble salts is 1.4 %, from then chlorine - ions - 0.04 % sulphate-ion - 0.22 %. Number of stems in the area of 1 m² - 208 – 348 pieces, length of spike is 7.5 – 7.6 cm. Average productivity has been made 27.8 centner ha⁻¹.

713. Soils of third site are low saline (0.2 % of salts in the plowing layer). Wheat grows well at the bottom and on the slop of the furrows where favorable water and salt soil regimes are formed. Wheat growth on the slop of furrow in average is 57 – 59 cm, at the bottom is 62.6 cm.

Number of spikes in 1 m² is 392 – 400 pieces. Productivity of wheat has been made 44 – 45 centner ha⁻¹.

714. Six sites were selected in order to find out the soils effect on wheat productivity in 2008-2009. Sites 1, 2, 5, 6 are low saline, site 3 is moderate saline and site 4 is high saline (Table 108). Wheat productivity at the sites 1 and 6 is very good, at the sites 2 and 5 - good and at the site 3 germination is very thinned. At the site 4, germination almost was not observed, or came up, but died after some due to high soil salinity.

715. High yield of wheat was in non saline and low saline soils where productivity has been made from 42 to 64 centner ha⁻¹, in high and very high saline soils productivity does not exceed 5 centner ha⁻¹ (Table 109).

Table 105. Groundwater salinity and chlroride content (2007 – 2008).

Allocation of sites where groundwater samples were taken	Grounwater level, cm	TDS, g l-1	EC, µs/cm	Cloride ion concentration	
				g l-1	(mg Eqv/100 g)
Winter wheat field, saline spot Plot 1	140 31.03.08	10.416	16.4	3.212	90.48
Plot 2	140 31.03.08	16.5	25.7	4.578	128.96
Plot 3	127 06.04.08	29.710	34.8	5.907	166.4

Table 106. Groundwater salinity at winter wheat field (2009)

Plots	Groundwater level, cm	Date	EC _{gw} , mS cm ⁻¹	TDS, g l ⁻¹	TDS, g l ⁻¹	Concentration g l ⁻¹							
						Cations				Anions			
						Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻
1	185	17 May	21.6	14.800	14.783	0.640	0.626	3.496	0.013	abs	0.638	4.114	5.256
2	155	17 May	17.1	13.088	13.083	0.710	0.608	2.760	0.019	abs	0.673	2.968	5.345
6	165	17 May	15.4	12.172	12.170	0.880	0.499	2.484	0.008	abs	0.502	3.069	4.728
1	190	31 May	20.8	15.356	15.343	0.474	0.864	3.358	0.018	abs	0.669	3.103	6.857
5	185	31 May	20.1	13.680	13.644	0.721	0.438	3.312	0.016	abs	0.615	3.878	4.664
6	205	31 May	21.0	15.012	14.988	0.577	0.664	3.588	0.019	abs	0.620	4.283	5.237
1	227	14 June	10.5	7.900	7.877	0.360	0.109	2.116	0.013	abs	0.508	1.585	3.186
5	165	14 June	16.4	11.740	11.740	0.520	0.353	2.990	0.027	abs	0.459	3.305	4.086
6	195	14 June	27.4	19.520	19.506	0.920	0.717	4.830	0.014	abs	0.571	5.936	6.518
Plots	Groundwater level, cm	Date	EC _{gw} , mS cm ⁻¹	TDS, g l ⁻¹	TDS, g l ⁻¹	Concentration g l ⁻¹							
						Cations				Anions			
						Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻
1	185	17 May	21.6	14.800	14.783	0.640	0.626	3.496	0.013	abs	0.638	4.114	5.256
2	155	17 May	17.1	13.088	13.083	0.710	0.608	2.760	0.019	abs	0.673	2.968	5.345
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1	227	14 June	10.5	7.900	7.877	0.360	0.109	2.116	0.013	abs	0.508	1.585	3.186
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6	195	14 June	27.4	19.520	19.506	0.920	0.717	4.830	0.014	abs	0.571	5.936	6.518
Plots	Groundwater level, cm	Date	EC _{gw} , mS cm ⁻¹	TDS, g l ⁻¹	TDS, g l ⁻¹	Concentration g l ⁻¹							
						Cations				Anions			
						Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻
1	185	17 May	21.6	14.800	14.783	0.640	0.626	3.496	0.013	abs	0.638	4.114	5.256
2	155	17 May	17.1	13.088	13.083	0.710	0.608	2.760	0.019	abs	0.673	2.968	5.345
6	165	17 May	15.4	12.172	12.170	0.880	0.499	2.484	0.008	abs	0.502	3.069	4.728
1	190	31 May	20.8	15.356	15.343	0.474	0.864	3.358	0.018	abs	0.669	3.103	6.857
5	185	31 May	20.1	13.680	13.644	0.721	0.438	3.312	0.016	abs	0.615	3.878	4.664
6	205	31 May	21.0	15.012	14.988	0.577	0.664	3.588	0.019	abs	0.620	4.283	5.237
1	227	14 June	10.5	7.900	7.877	0.360	0.109	2.116	0.013	abs	0.508	1.585	3.186
5	165	14 June	16.4	11.740	11.740	0.520	0.353	2.990	0.027	abs	0.459	3.305	4.086
6	195	14 June	27.4	19.520	19.506	0.920	0.717	4.830	0.014	abs	0.571	5.936	6.518

Table 107. Effect of soil salinity on growth, development and yield of winter wheat yield (2007-2008)

Plots #	Wheat variety	Salinity degree	No bushes, Pieces/m ²	No stens, Pieces/m ²	Stem lenght, cm	Length of spike, cm	Number of spikes in 1 sq.meter	Number of grains in 1 spike	Weight of grain in 1 sq.m ,g	Weight, of 1000 grain	Yield, t ha-1
1/1	Yubileinaya	high	152	152	27.3	4.1	38	15.2	2.709	19.53	0.27
1/2	Yubileinaya	high	196	212	32.1	4.8	20.4	21.9	7.383	26.03	0.73
2/1	Yubileinaya	moderate	152	348	48.6	7.5	248	38.4	27.932	28.98	2.79
2/2	Yubileinaya	moderate	176	308	49.6	7.6	312	39.9	27.814	29.21	2.78
3/1	Turkmenbashi	low	144	408	57.9	9.5	392	40.4	44.34	35.88	4.43
3/2	Turkmenbashi	low	152	448	59.0	11.0	400	45.4	45.47	35.80	4.54

Table 108. Soil salinity under winter wheat 2008-2009

Plots #	Depth, cm	Hydro-carbonates, %	Cl, %	TDS, %	EC			
					Aqueous extract		Suspension	
					1:5		1:10	
					mS	TDS	mS	TDS
1	0-30	0.030	0.047	0.780	2.22	4.27		
2	0-30	0.030	0.054	0.385	1.29	3.38		
3	0-30	0.037	0.061	0.475	1.62	4.35		
4	0-30	0.024	0.307	2.675	7.16	18.3		
5	0-30	0.030	0.016	0.135	0.413	1.08		
6	0-30	0.024	0.020	0.375	1.05	2.92		
1	0-30	0.030	0.034	0.255	0.795	0.425	2.49	1.33
2	0-30	0.024	0.019	0.200	0.617	0.329	1.70	0.94
3	0-30	0.030	0.465	2.425	6.63	3.60	15.3	9.3
4	0-30	0.030	0.016	0.135	0.413	0.220	1.08	0.59
5	0-30	0.037	0.019	0.140	0.444	0.237	1.14	0.69

Table 109. Effect of soil salinity on winter wheat yield (2009)

Plots #	TDS, %	Salinity degree	Wheat status	Number stems per 1 m ²	Wheat height, cm	Spike length, cm	Yield, t ha-1
1	0.31	Low	Very good	426	73.5	10.59	6.28
2	0.45	Low	good	332	60.7	7.78	4.26
3	1.92	High	Very sparse	260	44.7	5.68	0.47
4	2.67	Very high	No spikes	17	9.0	-	-
5	0.24	Non saline	good	456	80.87	8.80	5.08
6	0.286	Low saline	Very good	452	102.76	11.00	6.46

5.4.4.2 Experiment for cotton

716. Observation point for cotton development is located in the western part of “Parakhat” site of deqhqan community “Bugdaily” of Ak Bugday province. Total area of experiment field is 40 ha. Here 3 fields were observed - with good, middle and low conditions of cotton development.

717. Three sites were chosen for observing the level and mineralization of Groundwater and soil salinity (0-30 cm layer) under the cotton.

718. Soils of experiment field are highly salted. An upper layer of soils contains the main weight of salts. After irrigation salt mass is collected at the raised-bed of furrows, white salty crust forms and contains up to 5.0% of dense residue (Table 110).

719. After pre-plowing irrigation below soil crust, salinity quickly reduces to the moderate salinity level where according to the salt chemizm of cationic composition relates to sodium-calcium salinity type, according to anionic compositions to sulphate-chloride salinity type. Dynamics of soil salinity in different periods of plant development is given in the

720. Table 112.

721. In general soils are formed from prolyuvial deposition of light and moderate mechanical composition - shifting sand. This in considerable extent makes difficult to take ground water by an ordinary method. Level of Groundwater at observed field quite dynamic. In spring after pre-sowing irrigation or after first vegetation irrigation (11.05.08) level of Groundwater comes close to the day surface and then gradually reduces. Concentration of Groundwater is high (

722. Table 111).

723. The following field works were carry out at the experimental site: vegetation irrigations, additional fertilizing, fight against weeds, crop growth observations over cotton development, raised-bed tillage and cotton harvesting. Agro technical activities carried out at the experimental site for the vegetation period are presented in the Table 113.

724. Middle fibrous cotton of Iolatan-7 variety was planted. Cotton planting was carried out on 10 April 2008. Initial germination came up on 20 April 2008. Cotton density per 1 r. meter was made 5-6 plants. Booting stage started on 18 June 2008, when plant height in average has been made 22 cm. Observations over cotton growth and development were done at three fields: with good (field 1), moderate (field 2) and poor (field 3) cotton development (Table 107). In conditions of soil salinity number of bolls in the shrub and cotton weight considerably reduce as opened bolls become small.

725. Observation over soil salinity under cotton was carried out from the beginning till the end of cotton vegetation. Obtained data of salinity in ploughing layer show that at the field where cotton condition is good soil salinity varies from 0.1 to 0.3 % of dense residue. At the field where cotton development is moderate.

Table 110. Soil salinity on raised beds of experimental site at upper 2.5 cm soil depth

Date	EC measurements			TDS, %	Concentration, %							
	EC, mS cm-1	TDS, g l-1	Salinity, %		Cations				anions			
					Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻
04.05.2008	15.6	8.7	5.516	5.580	0.343	0.073	1.334	0.008	abs	0.024	1.514	2.220

Table 111. Groundwater salinity at experimental site

Date	Depth, cm	EC, mS cm-1	TDS, g l-1	TDS, %	HCO ₃ ⁻ , g l-1	Cl, g l-1
11.05.2008	98	20.1	11.4	14.940	0.468	2.954
meq/L					7.68	83.20

Table 112. Salt content at plowed soil depth at different cotton growing stages (Dry planting of cotton. Pic 4)

Soil depth, cm	EC		TDS, %	Soil salinity, %	Concentration, %							
	EC, mS cm-1	TDS, g l-1			Cations				Anions			
					Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻
1	2	3	4	5	6	7	8	9	10	11	12	13
20.04.2008. Initial germination of cotton												
0-30	1.57	0.93	0.725		0.108	0.029	0.069	0.008	abs	0.030	0.077	0.400
04.05.2008 .After post-sowing irrigation to enhance germination												
0-20	15.6	8.7	5.580	5.516	0.343	0.073	1.334	0.008	abs	0.024	1.514	2.220

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0-30	1.90	1.01	0.555	0.553	0.058	0.018	0.092	0.005	abs	0.030	0.096	0.254
22.06.2008. Early budding (good cotton development)												
0-30	0.927	0.496	0.310		0.040	0.004	0.051	0.004	abs	0.030	0.074	0.105
Moderate cotton development status												
0-30	1.80	0.100	0.510		0.040	0.012	0.142	0.005	abs	0.025	0.089	0.209
Poor cotton development status												
0-30	2.18	1.17	0.720		0.068	0.019	0.133	0.006	abs	0.030	0.107	0.357
04.07.2008. Budding and beginning of flowering (Poor cotton development status)												
0-30	1.83	0.98	0.595		0.062	0.016	0.098	0.010	abs	0.030	0.085	0.292
13.07.2008. Beginning of fruit formation (Good cotton development status)												
0-30	0.757	0.404	0.255	0.253	0.026	0.006	0.040	0.005	abs	0.037	0.026	0.113
Moderate cotton development status												
0-30	1.01	0.53	0.370	0.367	0.034	0.010	0.063	0.006	abs	0.030	0.033	0.191
Poor cotton development status												
0-30	1.29	0.54	0.440	0.438	0.046	0.010	0.075	0.075	abs	0.037	0.048	0.215
31.08.2008. Mass cotton bolls opening (Good cotton development status)												
0-30	1.15		0.235	0.234	0.020	0.006	0.041	0.006	abs	0.030	0.029	0.102
Good cotton development status												
0-30	1.47		0.455	0.453	0.052	0.017	0.061	0.008	abs	0.030	0.055	0.230
Poor cotton development status												
0-30	1.21		0.460	0.453	0.056	0.018	0.052	0.009	abs	0.030	0.050	0.238
02.11.2008 . After cotton harvesting (Development of cotton at highly saline soils)												
0-30	-	-	1.835	-	0.160	0.091	0.310	0.010	abs	0.024	0.444	0.785
0-30	-	-	2.310	-	0.165	0.128	0.402	0.013	abs	0.021	0.490	1.077
0-30	-	-	2.315	-	0.180	0.100	0.414	0.013	abs	0.024	0.472	1.051

Table 113. Farmer operation at experimental site

Farming practices	Dates of implementation
Land levelling (current)	01.01.2008
Fertilizer application (super phosphate= 120 kg ha-1)	15.01.2008
Chiseling and grinding	20.02.2008
Cut of temporal irrigation channels	30.02.2008
Cut of furrows (inter-row space =90 cm, length= 280m)	10.03.2008
Dry sowing of cotton	10.04.2008
Post sowing alternate irrigation application , 700 m ³ ha-1	28-29.04.2008
Cultivation and application mineral fertilizers (Ammonium Nitrate application 200 kg ha-1)	03.05.2008
1st irrigation (900 m3 ha-1)	08.05.2008
Cultivation and application of nitrogen fertilizers (Carbomide application 200 kg ha-1)	15.05.2008
2nd irrigation(850 m3 ha-1)	15.06.2008
3-rd irrigation(900 m3 ha-1)	05-06.07.2008
Cultivation and application of 4th irrigation (900 m3 ha-1)	10.08.2008
Cotton yields assessment and harvesting	Since 20.08.2008

726. Soil salinity mostly varies from 0.3 to 0.6 %. With increasing the salt content in the soil from 0.6 to 1.0 % cotton development status weakens.

727. Cotton growth in high saline soils (1.8-2.2 % of dense remain) does not exceed 10-15 cm, with 2-3 small poorly opened bolls. Productivity at such sites according to our observations does not exceed 1.5-3.0 centner ha⁻¹. In general cotton productivity at low saline site (field 1) at 0.1 – 0.3 % of dense remain has been made 29.8 centner ha⁻¹, at moderate saline site (field 2) where salinity of ploughing layer is 0.3 – 0.6 % productivity is made 21.3 centner ha⁻¹, at high saline site (field 3) where it exceeds 1.0% of dense remain – 12.9 centner ha⁻¹. At soil salinity of 1.8 – 2.0 % cotton productivity does not exceed 1.5 – 3.0 centner ha⁻¹.

728. Thus, carried out Research depending on the term of Project start allowed to obtain data of the effect of soil salinity on winter wheat productivity for two vegetation seasons and on cotton productivity for one vegetation period. Taking into account the importance of this experiment for explanation the effect of land degradation level on productivity of irrigated field and on working out of preventive measures for fighting against desertification, field Research of cotton irrespective of Project's terms completion (30.06.2009) would be continued till the end of vegetation period of 2009. Summarized data are given in the Table 115.

Table 114. Crop growth observations over cotton crop, in 1 m² area.

Date	Plant development stage	Plant height, cm	Number of flowers, pieces	Number of stems, pieces	Bolls pieces	
					Total	Opened
Field 1. Field with good cotton development status						
15.06.2008	Budding and beginning of flowering	39.6	4	5		-
13.07.2008	Beginning of fruit formation	44.4	6	5	4	-
10.08.2008	Starting cotton bolls bursting	68	18	5	26	10
31.08.2008	Mass cotton bolls bursting	83.8	-	5	75	61
Field 2. Field with moderate cotton development status						
15.06.2008	Budding and beginning of flowering	30.4	Singular	5		-
13.07.2008	Beginning of fruit formation	34.4	11	5		-
10.08.2008	Starting cotton bolls bursting	42	3	5	3	8
31.08.2008	Mass cotton bolls bursting	74	-	5	0	35
Field 3. Field with poor cotton development status						
15.06.2008	Budding and beginning of flowering	29.8	Singular	5	bs	-
13.07.2008	Beginning of fruit formation	34.4	11	5		-
10.08.2008	Starting cotton bolls bursting	43.2	4	5	3	10
31.08.2008	Mass cotton bolls bursting	56.2	-	5	4	29

Table 115. Effect of salinity to winter wheat and cotton yield

Winter wheat,2008		Winter wheat,2009		Cotton, 2008	
TDS, %	Yeld, t ha-1	TDS, %	Yeld, t ha-1	TDS, %	Yeld, t ha-1
3.50	0.27	0.31	6.28	0.15	2.98
1.68	0.73	0.45	4.26	0.45	2.13
0.46	2.79	1.92	0.47	1.00	1.29
0.52	2.78	2.67	0	1.90	0.23
0.20	4.43	0.24	5.08		
0.19	4.54	0.29	6.46		

729. According to the data from Table 115 graphs were formed for cotton and winter wheat effect on soil salinity.

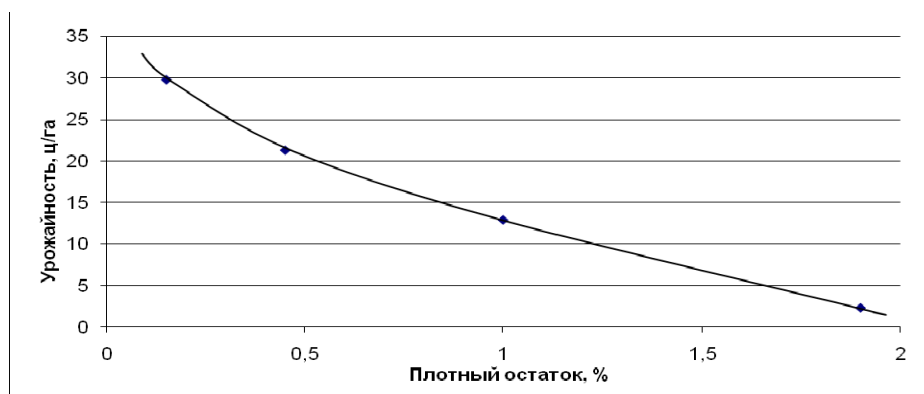


Figure 95. Cotton – 2008.

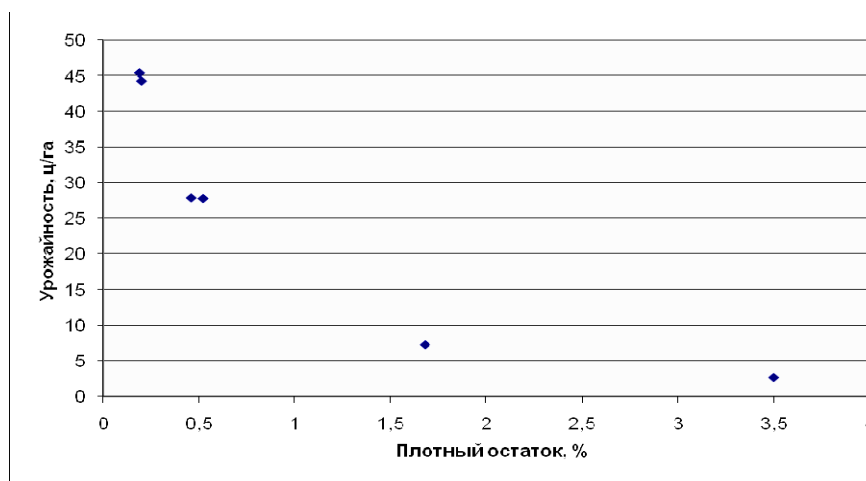


Figure 96. Winter wheat - 2008.

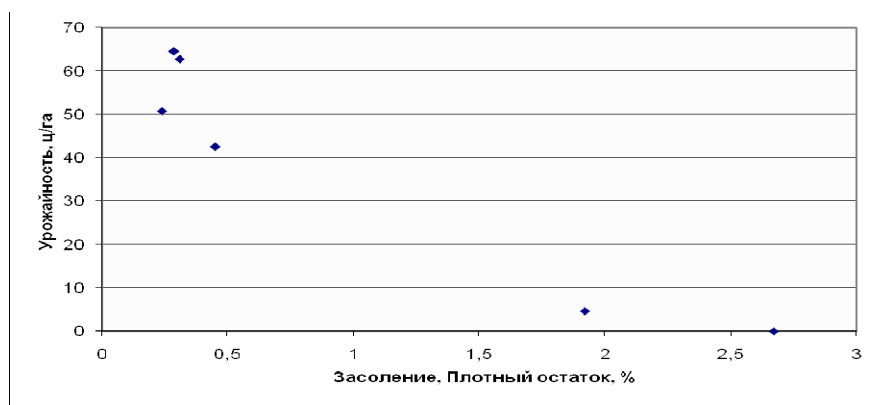


Figure 97. Winter wheat – 2009

5.4.5 Conclusions

730. Soil salinity is closely connected to the depth and mineralization of Groundwater and to the economic activities of human being. At the territory of irrigated area Groundwater are laid at the depth from 0.9 to 1.4 m under cotton, from 1.55 to 2.05 m under wheat.

731. Groundwater are high mineralized: under wheat 7.9 – 19.0 g l-1, in salt composition dominates from anions - chlorid ions, from cations - sodium.

732. Degree of soil salinity at the major part of crops is low saline, at the minor part of the territory is moderate and high saline.

733. Graph of effect of cotton and wheat productivity on salinity degree of irrigated field was built and close connection was installed.

5.5 Turkmenistan: Activity 3. Farmer participatory trials for validation, fine tuning and development of new resource conserving technologies.

5.5.1 Introduction

734. In agriculture conditions of Turkmenistan working out of resource saving technologies of wheat cultivation is carried out by the method of planting wheat to the cotton. After raw cotton harvesting on existing raised-beds possibility is created for using more economical agro technologies according to the following principles:

- absence or reduction of soil tillage (for the account of exception of plowing, leveling, furrow cutting etc.);
- retention of plants' residues;
- usage of crop rotations.

735. Minimal and zero till of soil takes place at such technology. Minimal till includes one or number of cultivations to the small depth. Planting is carried out with creation of mulch layer from cotton stubble. Zero till is characterized by the denial of all the types of mechanical soil hoeing.

736. In Turkmenistan since 2008 burning of plants' residues especially straw has not been carried out after winter wheat harvesting. In this relation great attention is paid to this research direction.

5.5.2 Objectives

737. To arrange the experiments for minimum soil tillage and to find out economic suitability of using resource saving technologies in industrial conditions.

5.5.3 Materials and Methods

738. Experimental sites with total area 34.2 ha were chosen from two farmers for carrying out Research in 2007-2008.

739. In relation to mention above we carried out experiments in two variations: 1-traditional method of wheat planting; 2- wheat planting to the cotton, advanced method (Table 3.1).

740. Soil preparation for wheat planting to the cotton includes the preparation and application of mineral fertilizers. Super phosphate of 300 kg ha⁻¹ was applied, after that chiseling was carried out in two-three traces by the cultivator CHKU- 4. Seeds' cleaning was done by the cleaning aggregate Pektus. Seeds were treated by the drug "Divident" with norm of 1 liter per ton of seeds.

741. According to the obtained results during vegetation years 2008-2009 wheat plantings to the cotton were increased to 1060 ha (advanced technology), and wheat planting to wheat with plants' residues soil plowing to the area of 2100 ha.

5.5.3.1 Study site

742. Investigated site is located at the territory of d/c "Bugdaily".

5.5.4 Results and discussions

743. Planting was carried out on 25-30 October by the planter SZU-3.6, seeds rate is 180 kg ha⁻¹ or 4.2 million grains ha⁻¹ at the weight of 42 g per 1000 grains. First vegetation irrigation was done on 1-6 November. Germination appeared on 9-14 November. Nitrogen fertilizers were applied twice at a rate of 300 kg ha⁻¹ and four irrigations were carried out during vegetation period.

744. At traditional method of wheat cultivation, too much weeds grow at the field such as: wind barley, oat grass, reed, ribbon grass, rye grass, trailing bindweed and others. That is why is necessary to use herbicides against weeds. Topik and Khussar were used at the experiments.

745. At advanced technology (planting to cotton) herbicides are not required as weeds almost do not grow.

746. Plants' residues impact on the temperature and biological potency of soil. In soil with mixed plants' residues vital function of soil micro organism becomes more active.

747. At assessment of the plants' residues influence on the temperature and soil moisture was determined that soil moisture with plants' residues for 30-35% more, temperature is lower for 5-100C then in the soils without plants' residues.

748. According to the data of scientific Research application of N, P and K according to optimal proportions stipulates productivity increasing for 10-15% in comparison with only nitrogen application.

749. The whole complex of implemented agro technical activities was studied in order to make comparative assessment of traditional and advanced technologies of winter wheat cultivation at the experimental sites.

750. After grain harvesting at the experimental site by traditional method productivity has been made 36.5 centner ha⁻¹, and at new (offered) technology - 34.7 centner ha⁻¹. In spite of productivity reduction for 1.8 centner ha⁻¹ at advanced technology according to the Table 116 of comparative assessment of expenses for the account of reduction of agro technical activities (10 industrial operations are not included) economy for 1 ha is made 360 thousand 472 manat, total cost for 1 ha of winter wheat cultivation reduces for 46.2%.

Table 116. Economic assessment of different winter wheat sowing methods in 2007 - 2008

№	Farming practices	Expenses incurred in winter wheat cultivation, Turkmen manat (from 1 January 2009 5000 = 1 DTM).	
		Traditional method	Advanced technology
1.	2.	3.	4.
1.	Cutting of temporal channels for pre-tillage irrigation	3075	-
2.	pre-tillage irrigation	12264	-
3.	Covering of terminal channels with earth	12332	-
4.	Fertilizer application	26772	26772
5.	Tillage	63620	-
6.	Levelling	43100	-
7.	chiseling	1130	-
8.	Chiseling with grinding and harrowing	16430	-
9.	Irrigation channels construction	14473	-
10.	Temporary irrigation network construction	4166	-
11.	Seeds treatments	75000	75000
12.	Transportation of seeds to the planter	70300	70300
13.	Sowing	46680	46680
14.	1 st irrigation	10629	10629
15.	Fertilizer application (1 st top dressing)	26772	26772
16.	2 nd irrigation	10629	10629
17.	Herbicides application	179712	-
18.	Fertilizer application (2 nd top dressing)	26772	26772
19.	3 rd irrigation	9811	9811
20.	4 th irrigation	9811	9811
21.	Harvesting of wheat	106662	106662
Total		780310	419838

751. As it was mentioned above in 2009 winter wheat planting to the growing cotton were carried out at big areas as well as after wheat with plants' residues. Obtained results showed that in both variations results were good and productivity in average has been made from 35 to 40 centner ha⁻¹.

752. In the second year also were carried out Research on studying the application of different rates of fertilizers for the wheat's productivity at different planting methods.

753. In first treatment wheat was planted to the cotton at the area of 0.3 ha in three replications. Research was carried out in three variations.

754. In first variation 500 kg ha⁻¹ or (170 kg d.v.) of ammonium nitrate and 200 kg ha⁻¹ (20 kg d.v.) of super phosphate ammoniated was applied.

755. In the second variation ammonium nitrate of 625 kg ha⁻¹ (212 kg d.v.) (25 kg d.v) was applied.'

756. In the third variation ammonium nitrate of 625 kg ha⁻¹ (212 kg d.v.) and super phosphate ammoniated of 1000 kg ha⁻¹ (100 kg d.v.).

757. Super phosphate ammoniated contains 10-11% P₂O₅ and 9-10% N.

758. Research results of different rates of fertilizer application on winter wheat productivity are shown in the Table 117.

Table 117. Effect of different rates of fertilizers application on winter wheat yield

№	Fertiliser rate, kg ha ⁻¹	Number of spikes in 1 m ²	Number of grain in 1 spike	Weight of 1000 seeds, g	Yield, t ha ⁻¹
1	N-170, P ₂ O ₅ -20	350	30	36	3.85
2	N-212, P ₂ O ₅ -25	360	32	40	4.43
3	N-212, P ₂ O ₅ -100	370	35	42	4.87

759. As seen from the Table the highest yield was obtained in the third variation, productivity of which in comparison with first variation is higher for 10 centner ha⁻¹.

760. In the second treatment two experiments were carried out for wheat planting without cleaning from chaff and plant residues and with application of different rates of fertilizers.

761. In the first variation 500 kg ha⁻¹ (170 kg d.v.) of ammonium nitrate and 200 kg ha⁻¹ (20 kg d.v) of ammoniated super phosphate.

762. Effect of different rates of mineral fertilizers on winter wheat productivity at ploughing without chuff and plant residues cleaning are given in the Table 118.

Table 118. Effect of different rates of fertilizers application on winter wheat yield

№	Fertilisers rates, kg ha-1	Number of spikes in 1 m ²	Number of grain in 1 spkie	Weight of 1000 seeds, g	Yeld, t ha-1
1	N-170, P ₂ O ₅ -20	365	32	37	4.08
2	N-212, P ₂ O ₅ -25	372	34	39	4.42

763. According to the obtained results productivity increases up to 44.2 centner ha⁻¹ at fertilizers application with rate of N-212 kg ha⁻¹ and P₂O₅-25 kg ha⁻¹.

5.5.5 Conclusions

764. 1. Offered advanced technology stipulates to moisture collection, evaporation reducing, eliminates the risk of water and wind erosion. As a result soil fertility increases, soil structure improves and fuel consumption reduces. Costs for one ton of wheat reduce almost in two times at this technology.

765. 2. Rates of fertilizers N-212, P₂O₅-100 at winter wheat planting to the cotton stipulate productivity increasing up to 10 centner ha⁻¹ in comparison with other treatments (N-170, P₂O₅-20 и N-212, P₂O₅-25).

766. 3. At planting winter wheat to wheat by plowing without cleaning from chuff and plant residues with applying fertilizers at a rate of N-212 kg ha⁻¹ and P₂O₅ -25 kg ha⁻¹ productivity increases up to 44.2 centner ha⁻¹ against 40.8 centner ha⁻¹ at a rate of N-170, P₂O₅ -20.

5.6 Turkmenistan: Activity 4. Develop permanent raised-bed planting systems for cotton-wheat systems, including mung beans

5.6.1 Introduction

767. Research activities of this experiment have begun in 2009.

5.6.2 Objectives

768. To create enough mung bean seed material in order to organize and carry out combined plantings in future.

5.6.3 Materials and Methods

769. Research was arranged at the experimental site of Turkmen scientific- research institute of grain crops. At the experimental site with area of 120 m² in February soil plowing was carried out with applying 250 kg ha⁻¹ of super phosphate. Mung bean of “Marjon” variety was planted on 25 April by row method. Mung bean seeds at a rate of 1 kg was taken from ICARDA office. Space between rows has been made 60 cm, between plants 6 – 8 cm.

5.6.4 Results and discussions

770. Table 119 contains the main phases of mung bean “Marjon” variety.

Table 119. Crop calendar of mug bean “Marjon” variety

Plant development stage	Sowing	Germination	Mass budding	Mass flowering	Mass fruit formation	Beginning of ripening
Date	25.04.09.	02.05.09.	17.06.09.	25.06.09.	29.06.09.	07.06.09.

771. The following types of agro technical activities were carried out during the whole vegetation period.

- on 10 May manual weeding was carried out.
- on 24 May - first vegetation irrigation.
- on 3 June - first cultivation of raised-beds.
- on 17 June - second vegetation irrigation.
- on 24 June - second raised-bed cultivation.
- on 30 June - third vegetation irrigation.
- on 13 July – fourth cultivation.

5.6.5 Conclusions

772. In general according to phenological and biometric characteristics this mung bean variety differs by big seeds and height not laying on the surface that is very important at combined planting. Detailed data of productivity will be collected at the end of vegetation period.

5.7 Turkmenistan: Activity 5. Maintaining favourable salt balance in raised-bed furrow system.

5.7.1 Introduction

773. From the first days of country's independence task for providing industrial independence of the country was put in front of agriculture workers. In order to carry out the given task President of Turkmenistan Saparmurat Turkmenbashi adopted the "Grain" Program. As a result of a number of activities carried out in frames of "Grain" Program, huge grain branches were created in agriculture of the country.

774. However, productivity of grain and cotton crops due to the moderate and strong salinity of irrigated lands and low technology of cultivation in some dehkan communities is still low.

5.7.2 Objectives

775. To study various technologies of winter wheat and cotton planting, irrigating and irrigation water saving.

5.7.3 Materials and Methods

776. In agronomy and land reclamation science mainly are used laboratory, vegetation and field methods which in combination with observations over plants and soil processes represent a very important instrument for learning the secrets of investigated phenomena. In this work, laboratory method was used for determination of parameters of water-physical features, soil salinity, moisture and mineralization degree of ground and irrigation waters.

777. Experiments were carried out in industrial conditions at the area of 50-55 hectares which were followed by farmers for evaluation of economic efficiency and irrigation water saving, as well as for various technologies of planting and cultivating wheat and cotton.

778. Measured plots were determined for carrying out phenological observations over growth and development of winter wheat in each experiment. 100 plants in each measuring plot were determined for observation according to the field experiment methodology [B.A. Dospekhov, 1979].

779. In the experimental variations of winter wheat and cotton, conditions of unity difference were followed, i.e. variations differed between each other by one investigated factor. Other factors which influence on winter wheat and cotton productivity were same. This requirement enables to compare data obtained from various experimental variations.

5.7.3.1 Study site

780. Research site for the experiment “Maintenance of favourable salt balance in raised-bed system” is located at the territory of dekhkan community “Bugdayli”, which is 70 km far from Ashgabat.

781. Climatic conditions of investigation site according to Ashgaban-Keshi weather station data have the following parameters:

- average annual air temperature is +16°C;
- average minimum air temperature is +10.5°C;
- average maximum air temperature is +23.2°C;
- duration of frost-free period is 232 days;
- average annual amount of precipitation is 234.8 mm.

782. Hydrographical network of investigation area consists of irrigation canals in land bed and open collectors with 2.5-3 m depth and 500-600 space between them which in general serve for irrigation water discharge.

783. The most common soils of experimental site are virgin and irrigated light sierozems and irrigated takyr like sierozems. Content of alplitite varies at the range of 25 to 65%. Volume weight of upper soil layer has been made – 1.39-1.42 g cm⁻³. Minimal moisture capacity is 20-24% from the weight of dry soil at 47% porosity from the volume (Table 120).

Table 120. Water physical parameters of soil at experimental site #6

Crop	Bulk density, g cm ⁻³	Porosity % vol	Field Capacity, % mass	Infiltration, m/day
Winter wheat	1.42	47	23.40	0.04
Cotton	1.39	47	23.68	0.011

5.7.3.2 Methodology

784. In Turkmenistan two technologies are mainly used for winter wheat cultivation: winter wheat planting on the raised-bed of furrow after pre-sowing irrigation and winter wheat planting on levelled surface after pre-sowing irrigation. Last time in some farms of the country where shortage of irrigation water and not planted lands is sharply observed winter wheat planting is carried out on the raised-bed of furrow to the growing cotton.

785. Advantage of planting winter wheat to the cotton on the raised-bed of furrow is the fewer rates of irrigation waters and free-flow raised-bed of furrow.

786. According to technical program NIR in order to save irrigation water used for pre-sowing irrigation and technical facilities needed for soil tillage as well as for maintaining

favourable salt balance in the raised-bed system in 2007-2009 experiments were carried out for cultivating winter wheat according to the following variations:

I treatment	Winter wheat planting on the raised-bed of furrow to the cotton without pre-sowing irrigation.
II treatment	Winter wheat planting on the raised-bed of furrow according to the existing technology after pre-sowing irrigation (control).
III treatment	Winter wheat planting to the cotton to the soil, subjected to erosion with carrying out leaching irrigation at a rate of 3500-4000 m ³ ha ⁻¹ .

787. During the period of investigations at the experimental site soil samples were taken before leaching and winter wheat planting at the beginning and at the end of vegetation period in order to evaluate the salinity of upper 30 cm layer at the raised-bed and at the bottom of furrow.

788. Salinity degree in 30 cm soil layer at the experimental site was evaluated according to the suspension electric conductivity of soil solution in proportion soil/water = 1/5. At the same time soil salinity evaluation was carried out according to the electric conductivity of soil suspension by the re-calculation coefficient of electric conductivity “K” accepted by international methodology FAO:

$$K = EC_e / EC_{1:5} [1]$$

here, EC_e – conductivity of saturated soil extract, $\frac{mS}{\tilde{n}i}$;

$EC_{1:5}$ – conductivity of soil suspension with corresponding volumes (weights) of dry soil to water, $\frac{mS}{\tilde{n}i}$.

789. Electric conductivity of saturated soil extract is calculated according to the formula:

$$EC_e = K * EC_{1:5} [2]$$

According to data of U.I. Shirokova (SANIIRI) in ratio water/soil = 1/5 re-calculation coefficient is $K=3.98$, and in ratio water/soil = 1/1 $K=3.64$.

We took $K=3.98$ at calculating the re-calculation coefficient K at $EC_{1:5}$.

790. Observations were carried out over the wells installed perpendicularly to open collectors for Groundwater’ mineralization and level changing. Samples of irrigation water also were taken for mineralization. Scheme of variations, discharge collectors and observation wells is shown in Figure 98.

791. Winter wheat planting of the first variation on the raised-bed of furrow to the cotton was carried out on 8 November 2007 and on 12 November 2008. In the second experimental

variation pre-sowing irrigation at a rate of $1200 \text{ m}^3 \text{ ha}^{-1}$ was done on 12 November 2007 and on 14 November 2008. Winter wheat planting of the second variation was carried out on 20 November 2007 and on 25 November 2008. Winter wheat planting to cotton of the third variations was carried out on 10 November 2007 after leaching irrigations.

792. In the first and third experimental variations on the raised-bed and at the bottom of irrigation furrows soil temperature regime was studied at the depth of 5; 10; 20 and 30 cm. Soil temperature measurement was done by Savin Thermometer. Plot experiments at the area of 24 m^2 ($10 \times 2.4 \text{ m}$) were carried out for studying the soil regime at the winter wheat field. In the third experimental variation plot was covered with chuff layer of 4-5 cm thickness.

5.7.4 Results and discussions

793. Analysis of soil suspension according to FAO methods showed that electric conductivity of soil extracts in first and second variations on the raised-bed of furrow varies at about $3.42 - 5.47 \text{ mS cm}^{-1}$. At the bottom of furrow in both variations soil electric conductivity is considerably low that at the raised-bed and has been made $1.49 - 2.86 \text{ mS cm}^{-1}$, which characterizes the soils as low saline. (Table 121).

794. At the site of third variation was determined beforehand that soils of this site are subjected to salinity and leaching is required. Samples analysis showed that lands are characterized by moderate and strong salinity degree $\text{ECe} = 6.72-9.45 \text{ mS cm}^{-1}$. That is why at this site leaching of cotton was carried out at a rate of $3500 \text{ m}^3 \text{ ha}^{-1}$ on 5 September 2007. As a result of leaching irrigations electric conductivity of the soil extracts reduces to $2.65-4.20 \text{ mS cm}^{-1}$, which correspond to low- and moderate saline soils.

795. Vegetation irrigations and observations over crop growth and development were carried out in all variations after winter wheat germination.

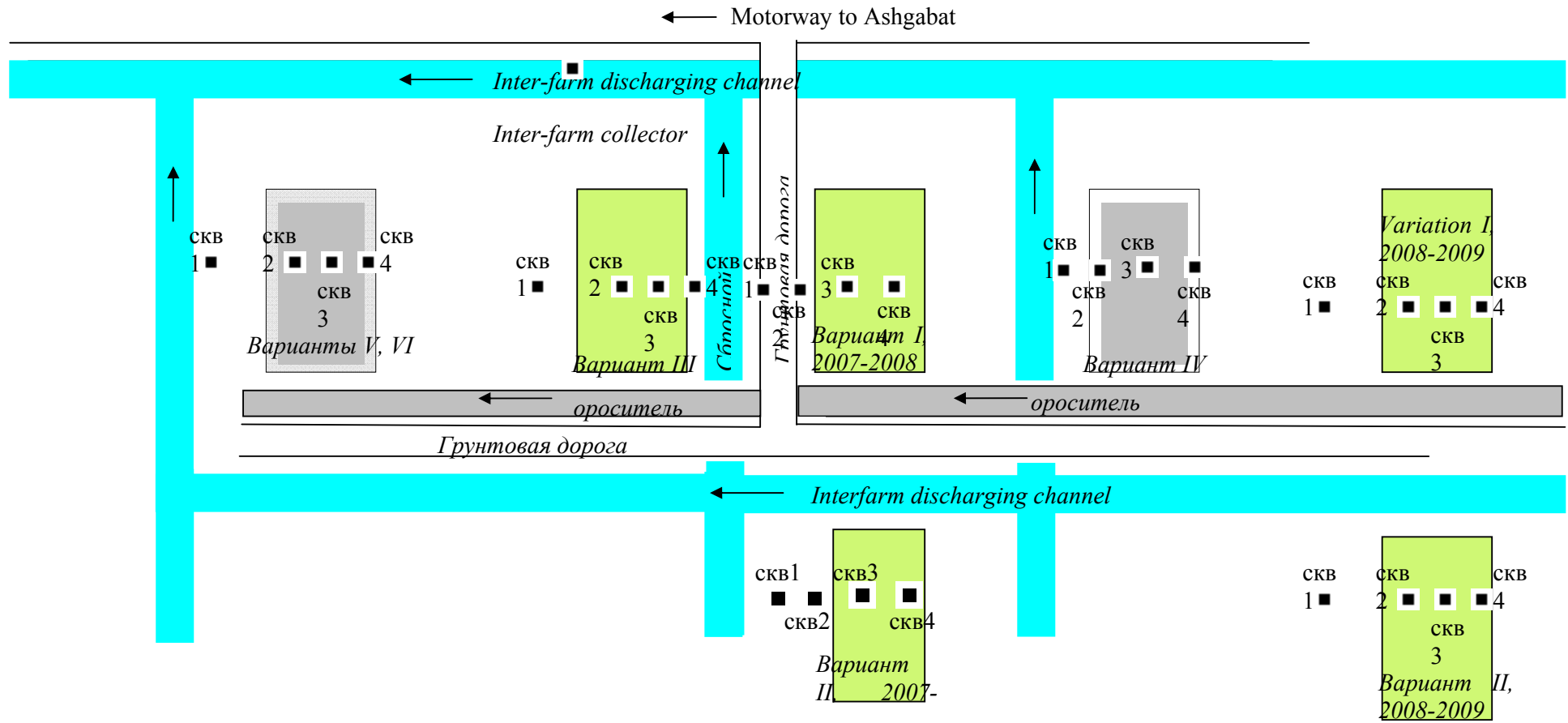
Table 121. EC of the soil at the 30 cm depth of the experimental site under winter wheat

№.№	Dates of soil sampling	date	Sampl ing place	EC		FAO soil salinity classification
				Soil suspension $EC_{1.5}^{(ms)}$ _{cm}	Soil extract $EC_e^{(ms)}$ _{cm}	
Treatment 1						
1	Before planting	02.11.07	G	1.14	4.54	Moderate saline
			D	0.375	1.49	Low saline
2	Before 1 st irrigation	16.11.07	G	1.05	4.18	Moderate saline
			D	0.96	3.82	Low saline
3	After irrigation	17.05.08	G	1.45	5.77	Moderate saline
			D	0.95	3.78	Low saline
4	Before planting	08.11.08	G	1.25	4.97	Moderate saline
			D	0.57	2.28	Low saline
5	Before first irrigation	19.11.08	G	1.21	4.81	Moderate saline
			D	0.75	2.98	Low saline
6	At the end of the vegetation season irrigation	15.05.09	G	1.58	6.28	Moderate saline
			D	0.82	3.26	Low saline
Treatment 2						
7	Pre-sowing irrigation	8.11.07	-	0.85	3.38	Low saline
8	Before planting	18.11.07	G	0.86	3.42	Low saline
			D	0.72	2.86	Low saline
9	Before 1 st irrigation	20.01.08	G	1.25	4.97	Moderate saline
			D	1.10	4.38	Moderate saline
10	After irrigation	12.06.08	G	1.05	4.18	Moderate saline
			D	0.94	3.74	Low saline

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11	Pre-sowing irrigation	08.11.08	-	0.98	3.9	Low saline
12	Before planting	23.11.08	G	0.78	3.10	Low saline
			D	0.87	3.46	Low saline
13	Before 1 st irrigation	13.01.09	G	0.82	3.26	Low saline
			D	0.85	3.38	Low saline
14	After irrigation	16.05.09	G	0.84	3.34	Low saline
			D	0.79	3.14	Low saline
Treatment 3						
15	Before leaching	04.09.07	G	2.39	9.45	High saline
			D	1.69	6.72	Moderate saline
16	After leaching	30.09.07	G	1.05	4.20	Moderate saline
			D	0.66	2.65	Low saline
17	Before planting	06.11.07	G	1.60	6.37	Moderate saline
			D	1.47	5.85	Moderate saline
18	Before 1 st irrigation	15.11.07	G	1.65	6.57	Moderate saline
			D	1.38	5.49	Moderate saline
19	After irrigation	19.05.08	G	2.58	10.27	High saline
			D	1.98	7.88	Moderate saline
20	Before leaching	07.09.08	-	2.45	9.75	High saline
21	After leaching	12.10.08	-	1.76	7.0	Moderate saline
22	Before planting	20.10.08	-	1.87	7.44	Moderate saline
23		06.11.09	-	1.93	7.68	Moderate saline
24	After irrigation	20.05.09	-	2.00	7.96	Moderate saline

Figure 98. Location scheme of treatments, irrigation canals, discharge collectors and observation wells at the experimental site No. 5



796. In all experimental variations according to “Irrigation regimes of agriculture in Turkmenistan (Ashgabat, 1990), irrigation rates and dates were determined in V hydro module area of Prikopetdag sub-zone. According to this regime 4 vegetation and 2 pre-vegetation (before ploughing and before planting) irrigations are offered for winter wheat cultivation. (Table 122).

797. Having analyzed the data of irrigation regime, it was determined that minimum irrigation rate was in the variation of winter wheat planting on raised-bed of the furrow to the cotton. Pre-plowing irrigation at a rate of $600 \text{ m}^3 \text{ ha}^{-1}$ and pre-sowing irrigation at a rate of $1200 \text{ m}^3 \text{ ha}^{-1}$ were required in the control variation of winter wheat planting on the raised-bed of furrow according to the existing technology. Leaching irrigations at a rate of 3500 and $4000 \text{ m}^3 \text{ ha}^{-1}$ were carried out in the third experimental variation of winter wheat planting on the raised-bed of furrow. In 2007 soil leaching in the third variation was done to cotton. However as a result of this leaching soil was washed unevenly. High soil salinity of 4.20 mS cm^{-1} was observed at the raised-bed of furrow and at the bottom of furrow - 2.65 mS cm^{-1} , which according to FAO classification characterize moderate and low degree of soil salinity. In 2008 leaching was carried out on leveled field surface at a rate of $4000 \text{ m}^3 \text{ ha}^{-1}$ in two replications. Before leaching electric conductivity of soil extract was 9.75 mS cm^{-1} , after leaching it reduced to 7.0 mS cm^{-1} , characterizing the soil in third variation as moderate saline.

798. Soil moisture and irrigation rates were determined before and after vegetation irrigation. (Table 123). According to the data from Table 123 soil moisture before irrigation in all experimental variations was approximately similar and varied from 16.95 to 19.60 % of dry soil weight. After irrigations moisture has been made 23.4% of dry soil weight and corresponds to its minimum moisture capacity.

Table 122. Farming practices in 2007-2009 at experimental site #6 occupied by winter wheat crop

№	Farming practices	Dates of implementation			
		1	2	3	
2007-2008					
1	Current leveling	-	01.11.07	-	
2	pre-tillage irrigation (m = 600 m3 ha-1)	-	09.11.07	-	
3	Application mineral fertilizers (P=400kg ha-1, manure =10-1 t ha-1)	07.11.07	11.11.07	10.11.07	
4	Tillage	-	05.11.07	-	
5	Cutting of temporal irrigation channels	-	10.11.07	-	
6	Soil leaching(m = 3500 m3 ha-1)	-	-	05.09.07	
7	Pre-sowing irrigation (m=1200m3 ha-1)	-	12.11.08	-	
8	Crop sowing	08.11.07	20.11.07	10.11.07	
9	Pre-sowing irrigation, m3 ha-1	-	1800	3500	
10	Irrigation within crop season	1. m = 900 m3 ha-1	18.11.07	22.01.08	20.11.07
		2. m = 800 m3 ha-1	30.03.08	28.03.08	28.03.08
		3. m = 800 m3 ha-1	20.04.08	10.04.08	17.04.03
		4. m = 800 m3 ha-1	08.05.08	15.05.08	22.05.08
11	Total irrigation rate, m3 ha-1	3300	3300	3300	
12	Gross irrigation rate, m3 ha-1	3300	5100	6800	
2008-2009					
1	Land leveling	-	07.11.08	08.10.08	
2	pre-tillage irrigation (m = 600 m3 ha-1)	-	08.11.08	25.10.08	
3	Application mineral fertilizers (P= 400kg ha-1, manure=10 15t ha-1)	06.11.08	06.11.08	07.11.08	
4	Tillage	-	12.11.08	05.09.08	
5	Cutting of temporal irrigation channels	-	10.11.08	25.10.08	
6	Soil leaching (m = 4000 m3 ha-1)	-	-	10.09.08	
7	Pre-sowing irrigation (m=1200m3 ha-1)	-	14.11.08	-	
8	Crop sowing	12.11.08	25.11.08	28.10.08	
9	Pre-sowing irrigation, m3 ha-1	-	1800	4600	
10	Irrigation within crop season	1. m = 900 m3 ha-1	22.11.08	15.01.09	08.11.09
		2. m = 800 m3 ha-1	10.03.09	22.03.09	27.03.09
		3. m = 800 m3 ha-1	12.04.09	18.04.09	14.04.09
		4. m = 800 m3 ha-1	10.05.09	12.05.09	17.05.09
11	Total irrigation rate, m3 ha-1	3300	3300	3300	
12	Gross irrigation rate, m3 ha-1	3300	5100	7900	

Table 123. Estimated and actual irrigation rates of winter wheat, site №6

Treatments	№ irrigation	Dates of irrigation	Soil moisture, mass%		Irrigation rate, m3 ha-1	
			Pre-irrigation	Post-irrigation	estimated	actual
I treatment (2007-2008)	1	18.11.07	17.55	23.4	877.5	900
	2	30.03.08	18.25	23.4	772.5	800
	3	20.04.08	18.20	23.4	780.0	800
	4	08.05.08	17.80	23.4	840.0	800
Total					3270.0	3300
II treatment (2007-2008)	1	22.01.08	19.60	23.4	570.0	900
	2	28.03.08	17.80	23.4	840.0	800
	3	10.04.08	18.20	23.4	780.0	800
	4	15.05.08	18.75	23.4	697.5	800
Total					2887.5	3300
III treatment (2007-2008)	1	20.11.07	17.30	23.4	915.0	900
	2	28.03.08	18.30	23.4	765.0	800
	3	17.04.03	18.75	23.4	697.5	800
	4	22.05.08	17.80	23.4	840.0	800
Total					3217.5	3300
I treatment (2008-2009)	1	22.11.08	16.95	23.4	967.5	900
	2	10.03.09	17.70	23.4	855.0	800
	3	12.04.09	18.20	23.4	780.0	800
	4	10.05.09	18.75	23.4	697.5	800
Total					3300.0	3300.0
II treatment (2008-2009)	1	15.01.09	17.25	23.4	922.5	900
	2	22.03.09	18.00	23.4	810.0	800
	3	18.04.09	18.20	23.4	780.0	800
	4	12.05.09	18.60	23.4	720.0	800
Total					28582.5	3300.0
III treatment (2008-2009)	1	08.11.09	19.00	23.4	660.0	900
	2	27.03.09	18.00	23.4	810.0	800
	3	14.04.09	18.50	23.4	735.0	800
	4	17.05.09	17.80	23.4	840.0	800
Total					60210.0	3300.0

799. Comparing the results of first and second experimental variations of winter wheat planting on the raised-bed of furrow shows that irrigation water saving in the first variation for the account of no irrigation before plowing and planting is made 1800 m³ ha⁻¹. At winter wheat planting on the raised-bed of furrow in the moderate saline soils, raised-bed of furrow serves as

a place for salt collection. Thus, according to two-year investigation data, winter wheat planting to the saline soil is not effective. That is why we recommend to plant winter wheat at the leveled field after leaching and pre-sowing irrigations.

800. Crop growth observations over winter wheat showed that in the first variation first germination came up on 12 November 2007 and tillering stage started on 2 December. In the second variation due to late wheat planting (20.11.07), germination came up on 26.11.07 and finished on 30.11.07. The same growth of winter wheat also observed in all the experimental variations in 2008. In general, in the first variation all the stages start and finish earlier then in second variation and full ripeness starts for 3-6 days earlier (Table 124).

Table 124. Crop growth observations over growth and development of winter wheat

treatments	Stages													
	germination		tillering		Booting		ear formation		flowering		waxy ripeness		Full ripeness	
	beginning	ending	beginning	ending	beginning	ending	beginning	ending	beginning	ending	beginning	ending	beginning	ending
2007 – 2008														
I	12.11.07	22.11.07	02.12.07	27.02.08	15.03.08	15.04.08	20.04.08	05.05.08	06.05.08	15.05.08	16.05.08	20.05.08	05.06.08	10.06.08
II	26.11.07	30.11.07	06.12.08	29.02.08	17.03.08	16.04.08	15.04.08	10.05.08	15.05.08	20.05.08	22.05.08	26.05.08	01.06.08	15.06.08
III	17.11.07	21.11.07	04.12.07	27.02.08	18.03.08	22.04.08	28.04.08	07.05.08	17.05.08	22.05.08	23.05.08	30.05.08	02.06.08	10.06.08
2008 – 2009														
I	06.11.08	23.11.08	22.11.08	08.02.09	19.02.09	06.03.09	15.04.09	23.04.09	28.04.09	07.05.09	13.05.09	19.05.09	20.05.09	27.05.09
II	21.11.08	30.11.08	31.11.08	14.02.09	28.02.09	15.03.09	23.04.09	03.05.09	01.05.09	12.05.09	15.05.09	22.05.09	26.05.09	04.06.09
III	09.11.08	24.11.08	27.11.08	17.02.09	04.03.09	22.03.09	28.04.09	07.05.09	07.05.09	19.05.09	21.05.09	28.05.09	29.05.09	05.06.09

801. At the winter wheat crops of 2007 the most density (270 plants per 1 m²) was observed in the first variations, where planting was carried out to the cotton on 08.11.07. In the second variation density per 1 m² has been made 229 plants. The highest actual productivity of winter

wheat – 43.4 centner ha⁻¹ – was determined in the first variation in 2008. The lowest density of 206 plants per 1 m² and low quality productivity of 17.4 centner ha⁻¹ was obtained in the third variation (Table 125). In 2008-2009 plants' density in the first variation in average has been made 269, in the second – 237, in the third – 218 plants per 1 m².

Table 125. Yields and economic parameters of different technologies of sowing winter wheat for 2007-2009.

Treatments	Yields, t ha ⁻¹	Gross irrigation rate, m ³ ha ⁻¹	Water expenses per 1 t, m ³ /t	Petrol expenses, L ha ⁻¹	Operational costs, Turkmen Manat ha ⁻¹
2007- 2008					
1	4.34	3300	760	17.69	2.17
2	4.13	5100	1230	32.27	12.74
3	1.74	6800	3910	17.69	2.17
2008- 2009					
1	4.55	3300	730	17.69	2.17
2	4.01	5100	1270	32.27	12.74
3	2.73	7900	2890	17.69	2.17

802. In order to evaluate economical rates at different winter wheat planting technologies rates of POL materials, needed per one hectare of arable land and costs for plowing and chiseling were taken according to the data of “Turkmenobakhyzmat” Association.

803. Calculations showed that at winter wheat planting on the raised-bed of furrow to the cotton, POL materials per 14.58 l ha⁻¹ and cost for agriculture works per each hectare for 10.57 manat less then in the variation of winter wheat planting after pre-sowing irrigation.

804. The main factors which determine soil salinity of experimental site is close level of Groundwater to land's surface and their high mineralization. Depth of Groundwater mainly forms under the influence of precipitations and vegetation irrigations. Depths of Groundwater' level for 2007-2008 and 2008-2009 agricultural years are shown in the graph. (Figure 99)

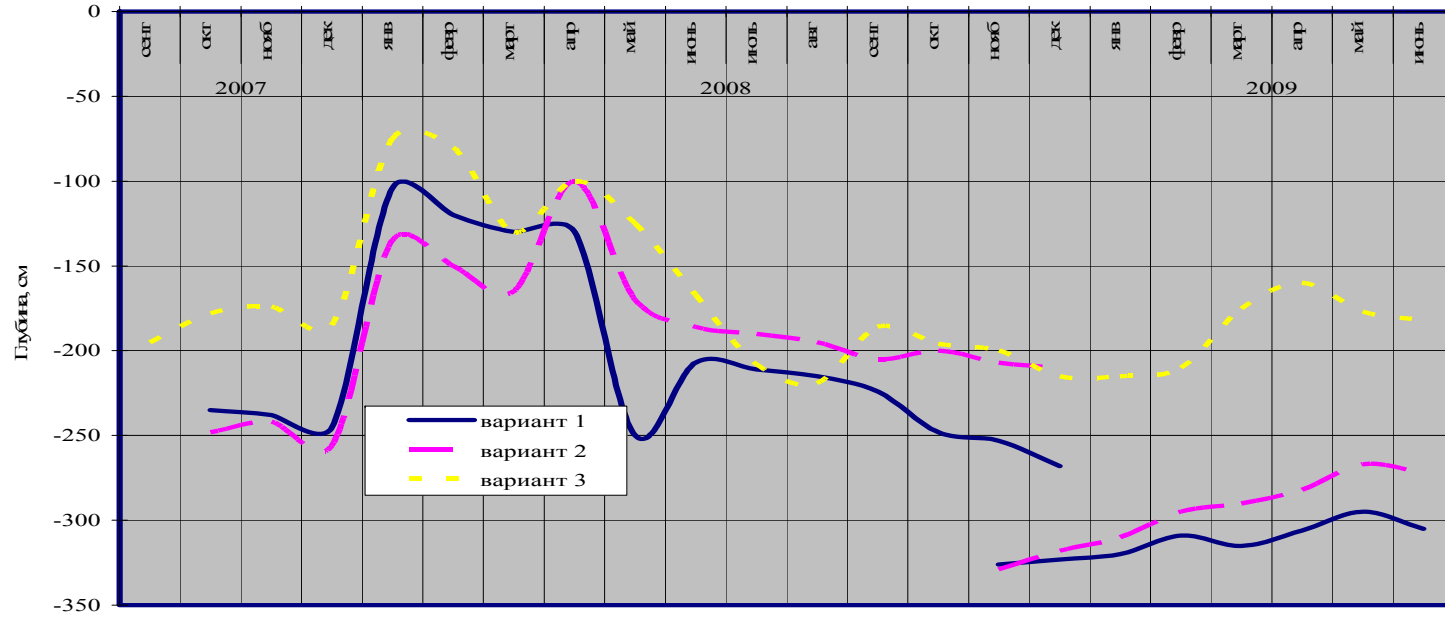


Figure 99 Graph of ground water level depth from land surface at the field occupied by winter wheat

805. As seen from Figure 99, during the period of abundant precipitation (December 2007 and March 2008) and during vegetation irrigation the ground water levels in all the variations sharply increased and were at the depth of 100-150 cm from land surface. The closest level was observed in the third variation at the depth of 80 cm from land surface. After stopping the winter wheat vegetation irrigations and with evaporation strengthening depth of ground water level gradually reduces.

806. In 2008-2009 wheat crops of first and second variations were transferred by farmers to another fields where level of Groundwater was at the depth of 2.8-3.0 m.

807. Electric conductivity of Groundwater in all the variations did not considerably change and maintained in the average at the level of 15 mS cm⁻¹, which corresponds to salt content of 10.5 g l⁻¹ (Figure 100). It should be pointed that in conditions of close ground water occurrence (1.5 – 2.0 m), as in the third variation, highly mineralized Groundwater are the main source of salinity.

808. Electric conductivity of irrigation water during the period of experiment carried out in 2007-2009 did not considerably changes from 0.66 to 1.20 mS cm⁻¹ (Figure 101). Together with this salt content in irrigation water relates to autumn-winter period related to hydro chemical regime of Amudarya river.

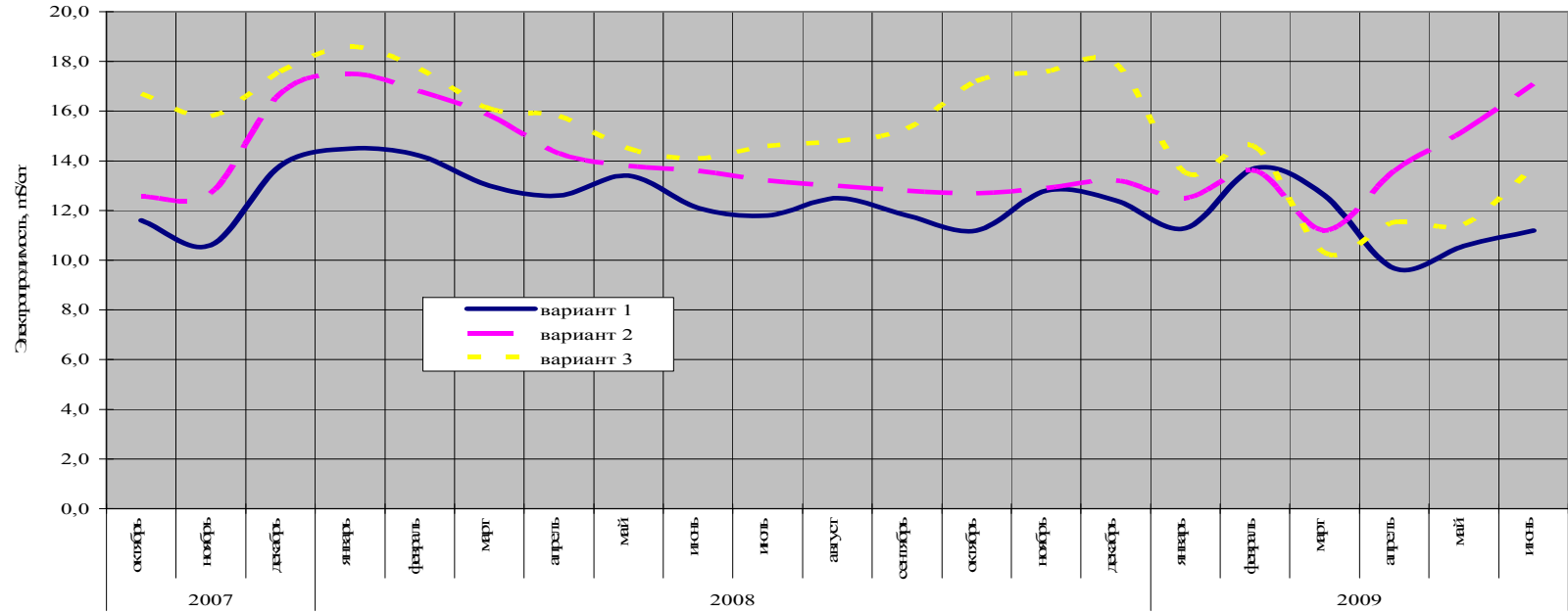


Figure 100. Changes in electric conductivity of the Groundwater on winter wheat fields.

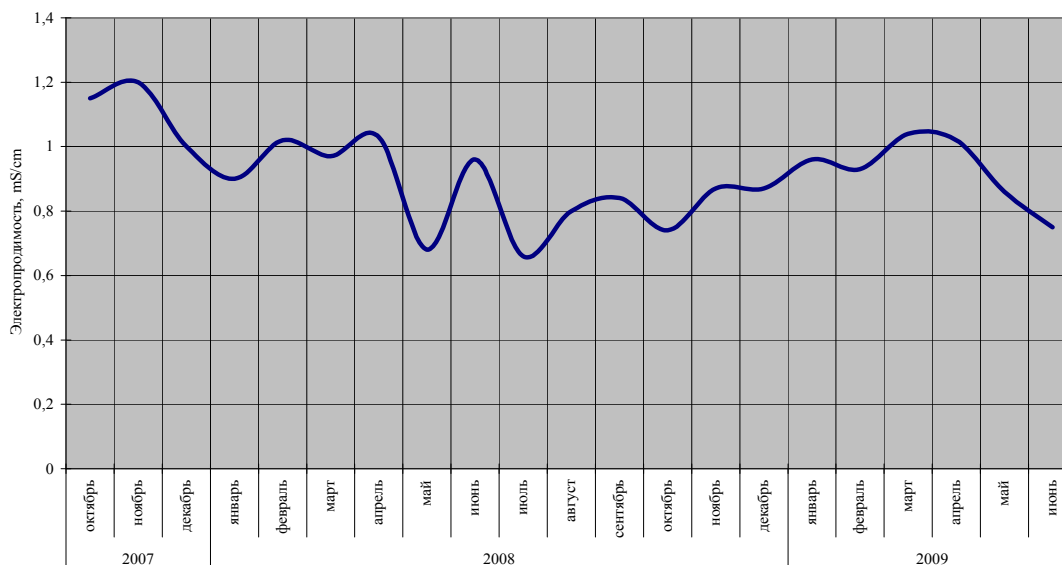


Рис.4. График изменения электропроводимости оросительных вод

Figure 101. Changes in electric conductivity of the irrigational water.

809. Mulching results of soil surface occupied by winter wheat, chuff with the thickness of 5-10 cm showed that under the chuff layer soil temperature for 1-9C0 lower then on the surface without chuff. Besides that soil had less temperature at all depths under the chuff then at plot without chuff (Figure 102).

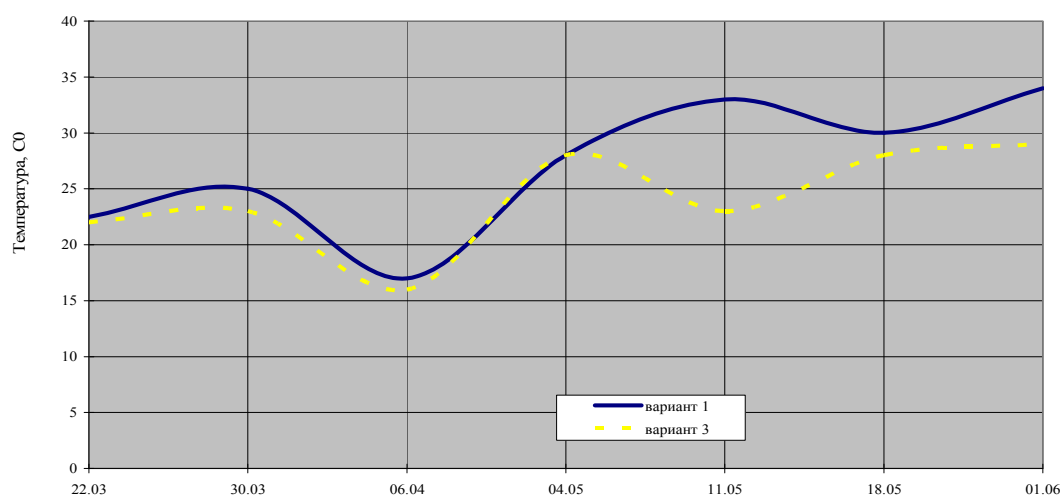


Figure 102. Temperature regime on the soil surface of winter wheat fields.

810. Experiments were carried out at the site occupied by cotton according to the following variations:

4 variation	Cotton planting on the raised-bed of furrow without pre-sowing irrigation. Area is 50 ha. Farmer is Myradov Meret.
5 variation	Cotton planting on the raised-bed of furrow according to the existing technology after pre-sowing irrigation (control). Farmer is Kazakov Kakadurdy.

811. Raised-bed and bottom of furrow with chuff layer of 2-4 cm were mulched for investigation of temperature regime in fifth variation at the plot of 2.4x10 m size. Experiment was carried out according to the configuration A where the space between rows was 90 cm and cotton planting was on the raised-beds of furrow. In the control variation cotton planting was carried out after pre-sowing irrigation at a rate of 1600 m³ ha⁻¹. Date of implementing agro technical activities at the experimental site occupied by cotton are given in the Table 126.

812. Results of laboratory analysis of soil samples from the fourth variation show that soils on the raised-bed and at the bottom of furrow before cotton planting and before irrigation are non saline and low saline with soil extract electric conductivity of E_{Ce}=1.15 – 2.51 mS cm⁻¹ (

813. Table 127). At the end of vegetation irrigation electric conductivity of soil extract on the raised-bed of furrow increases to 4.38 mS cm⁻¹, caused by salt collection on the raised-bed of furrow.

814. In the fifth variations before pre-sowing irrigation electric conductivity of soil extract has been made 6.96 mS cm⁻¹. Before cotton planting under the influence of pre-sowing irrigation at 1600 m³ ha⁻¹ electric conductivity of soil extract a little bit reduced and on the raised-bed of furrow has been made 6.77 mS cm⁻¹, and at the bottom – 6.88 mS cm⁻¹. At the end of cotton vegetation irrigations electric conductivity of soil extract on the raised-bed of furrow was equal to 14.48 mS cm⁻¹, having characterized the soil as high saline.

815. Electric conductivity of Groundwater at the beginning and at the end of vegetation did not considerably change 6.80-9.67 g l⁻¹, that can be referred to a high saline and saline group of waters (Figure 103). Electric conductivity of irrigation water till June did not change considerably (0.58-0.68 g l⁻¹) (Figure 103). At the end of vegetation mineralization of irrigation water considerably increases and reaches up to 2.09-2.57 g l⁻¹. Increasing of irrigation water mineralization at the end of cotton vegetation caused by lack of water and dilution with drainage water.

Table 126. Farming practices in 2007-2009 on experimental site #6 occupied by cotton

№	Farming practices	Dates of implementation	
		4	5
1	Current leveling	-	15.01.08
2	pre-tillage irrigation (m = 600 m ³ ha ⁻¹)	11.12.07	10.02.08
3	Tillage	24.12.07	21.02.08
4	Cutting of temporal irrigation channels $\ell=200-250$ m	18.03.08	14.03.08
5	Application mineral fertilizers (P400 kg ha ⁻¹ , N 300 kg ha ⁻¹)	20.03.08	15.03.08
6	Pre-sowing irrigation (m=1600m ³ ha ⁻¹)	-	29.03.08
7	Sowing	23.03.08	07.04.08
8	Pre-sowing irrigation, m ³ ha ⁻¹	600	2200
9	Irrigation during crop season, m ³ ha ⁻¹		
	1. m = 900 m ³ ha ⁻¹	06.04.08	18.04.08
	2. m = 800 m ³ ha ⁻¹	20.05.08	31.04.08
	3. m = 800 m ³ ha ⁻¹	29.06.08	10.05.08
	4. m = 800 m ³ ha ⁻¹	20.07.08	18.06.08
	5. m = 1000 m ³ ha ⁻¹	-	25.07.08
10	Total irrigation rate per season, m ³ ha ⁻¹	3300	4300
11	Total irrigation rate, m ³ ha ⁻¹	3900	6500

Table 127. Electrical conductivity (EC) at 30 cm soil depth at experimental site № 6, cotton planted

№№	Dates of soil sampling	date	Sampling place	EC		FAO soil salinity classification
				Soil suspension $EC_{1:5}^{(ms)}_{cm}$	Soil extract $EC_e^{(ms)}_{cm}$	
Treatment 4						
1	Before planting	21.03.08	G	0,588	2,35	Low saline
			D	0,29	1,15	Non saline
2	Before 1 st irrigation	01.04.08	G	0,63	2,51	Low saline
			D	0,33	1,31	Non saline
3	After irrigation	07.07.08	G	1,1	4,38	Moderate saline
			D	0,53	2,10	Low saline
Treatment 5						
4	Before planting	25.03.08		1,75	6,96	Moderate saline
5	Before planting	01.04.08	G	1,70	6,77	Moderate saline
			D	1,73	6,88	Moderate saline
6	Before 1 st irrigation	15.04.08	G	1,84	7,32	Moderate saline
			D	1,83	7,28	Moderate saline
7	After irrigation	29.07.08	G	3,64	14,48	High saline
			D	1,68	6,69	Moderate saline

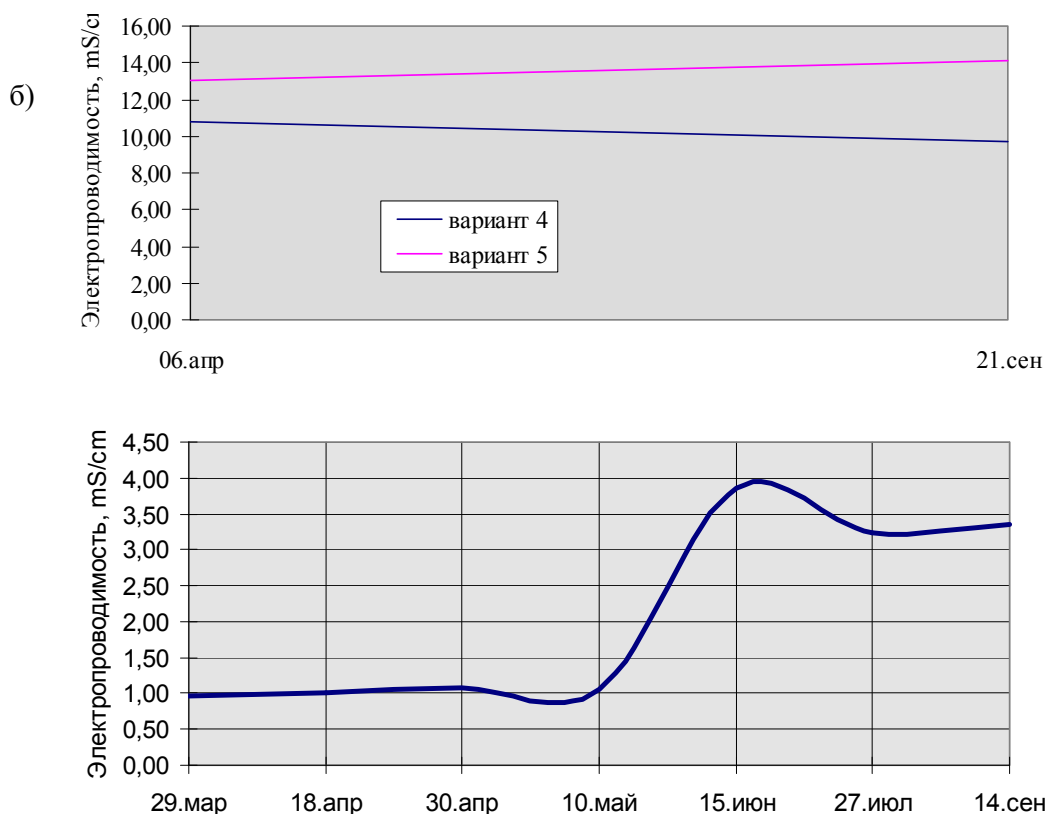


Figure 103. Graphs of electro conductivity changing: a) ground water; b) irrigation water at the cotton fields.

816. Depth of ground water occurrence in the fourth variation for the vegetation period in average changed in the interval of 1.25-1.75 m from surface. In the fifth variation where cotton is planted on the raised-bed of furrow after pre-sowing irrigation, level of Groundwater in March-April 2008 was at the depth of 1.8-2.0 m below land surface (Figure 104).

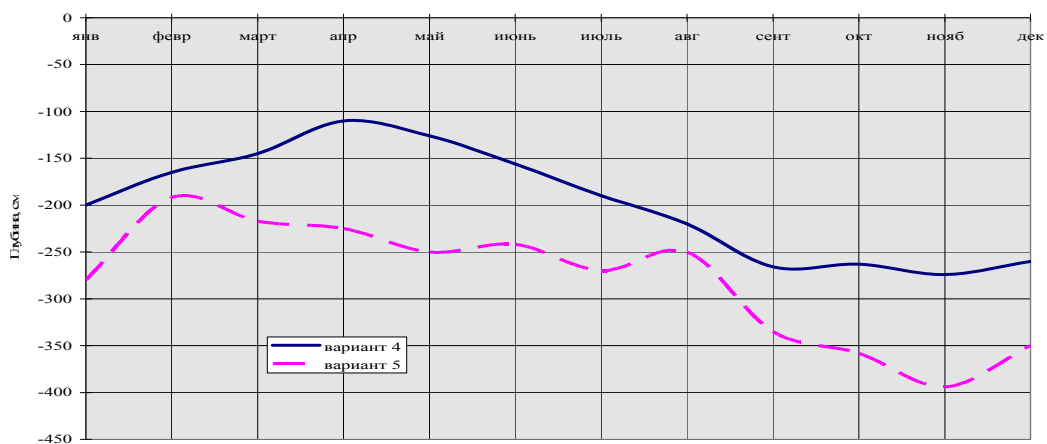


Figure 104. Graph of ground water depths below the land surface at the field occupied by cotton

817. Crop growth observations carried out at the experimental site showed that in the fourth variation where cotton was planted without pre-sowing irrigation all development stages start earlier then in the control variation (Table 128).

Table 128. Crop growth observations over growth and development of cotton

Phenological stages		Treatments	
		4	5
Crop emergence	Starting	02.04.087	05.04.08
	Ending	06.04.08	12.04.08
Leaves formation	Starting	20.04.08	30.04.08
	Ending	01.05.08	04.05.08
Budding	Starting	31.05.08	17.05.08
	Ending	20.06.08	20.06.08
Flowering	Starting	09.06.08	14.06.08
	Ending		
Bolls formation	Starting	13.06.08	18.06.08
	Ending		

818. In the fourth treatment pre-sowing irrigation with 1600 m³ha⁻¹ rate was reduced as well as the last vegetation irrigation with 1000 m³ ha⁻¹.

819. Cotton productivity in fourth variation with irrigation rate of 3900 m³ ha⁻¹ for 7 centners is more then in the control variation. Water rates per 1 centner of raw cotton in the fourth variation have been made 100 m³/c, and in fifth variation in two times more – 203 m³ ha⁻¹. Rates of POL materials per 1 ha in both variations are similar and have been made 32.27 t ha⁻¹. Costs for works spent on machine operators for soil tillage have been made 12.75 man ha⁻¹ (Table 129).

Table 129. Yields and economic parameters of different technologies of sowing cotton for 2008

Treatments	Yields, t ha ⁻¹	Gross irrigation rate, m ³ ha ⁻¹	Water expenses per 1 t, m ³ /t	Petrol expenses, L ha ⁻¹	Operational costs, Turkmen Manat ha ⁻¹
4	39	3900	100	32.27	12.74
5	32	6500	203	32.27	12.74

820. Curves' comparison of soil temperature on raised-bed of furrow at 5 cm depth at the cotton field showed that under the chuff layer soil had for 1-30C lower temperature then at the surface without chuff. The same temperature falling under the chuff layer was observed at 10; 20 and 30 cm depths of soil (Figure 105).

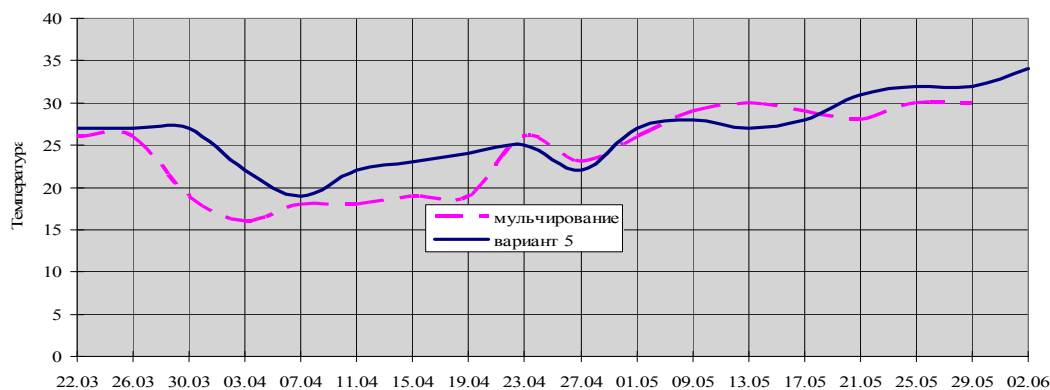


Figure 105. Temperature regime of soil on the raised-bed of furrow with 5 cm depth at cotton field

5.7.5 Conclusions

821. Results of implemented Research on maintaining a favorable salt balance in raised-bed system of winter wheat and cotton planting enabled to make the following conclusions:

822. 1. Raised-bed system of winter wheat and cotton planting has a number of advantages in comparison with planting at the leveled area after pre-sowing irrigation. In this planting method raised-bed of furrow moistens but not flooded and requires less irrigation water. Besides that, works for rollers' liquidation are not required before harvesting.

823. 2. This raised-bed system of winter wheat planting also has some disadvantages. At winter wheat planting on the raised-bed of furrow seeds are not covered well with soil that leads to reducing the seeds germination. However from the soil salt regime point of view the main disadvantage of raised-bed system is big collection of salts at the raised-beds in comparison with furrow's bottom. According to the data of implemented Research was determined that in the first and second variations of winter wheat planting electro conductivity of soil extract at the raised-bed before planting relatively has been made 4.54 and 0.86 mS cm⁻¹., and at the furrow's bottom - 0.38 and 0.72 mS cm⁻¹.

824. Similar saline regime at the raised-bed and at the bottom of furrow was observed in the raised-bed system of cotton planting. Low soil salinity at the bottom of furrow in the field, occupied by winter wheat and cotton provoked by leaching character of vegetation irrigations.

825. High electro conductivity of soil extract at the raised-bed of furrow indicates that in conditions of close occurrence of highly mineralized Groundwater on the soils which are subjected to moderate and high salinity, using the winter wheat planting on the raised-bed of furrow is not effective. That is why in the soils subjected to moderate and high salinity, winter wheat and cotton planting is reasonable to carry out at the leveled field after pre-sowing and leaching irrigations.

826. As the result of phenological observations over growth and development of winter wheat and cotton planted according to raised-bed system was determined that development stages of plants take place for 10-12 days earlier then in the control variations.

827. Data analysis of irrigation regime of various winter wheat methods showed that in the first variation due to no irrigations before plowing and planting irrigation water is saved at a rate of 1800 m³ ha⁻¹. In the third experimental variation where leaching irrigation was carried out total average irrigation rate for 2007-2009 has been made 7350 m³ ha⁻¹, that is for 2250 m³ ha⁻¹ more then in the control variation.

828. Winter wheat productivity for 2007-2009 in the first experimental variation has been made 44-45 centner ha⁻¹, in the second – 40-70 centner ha⁻¹, in the third – 22-35 centner ha⁻¹. Average water rates for two agricultural years per 1 centner of grain in the first variation has been made 74.50 m³/s, in the second – 125 m³/s, in the third – 340 m³/s. Costs for POL materials in first and third variations in average have been made 17.69 l ha⁻¹, and in the control – 32.27 l ha⁻¹. Costs for work of machine operators in the first and third variations were made 2.17 manat ha⁻¹, and in the control – 12.74 manat ha⁻¹.

829. The same economic rates were determined also for variation of cotton planting. Water rates per 1 centner of raw cotton in the variation of cotton planting at the raised-bed of furrow without pre-sowing irrigation have been made 100 m³/s, and in fifth variation taking into account the rates of pre-sowing and last vegetation irrigation – 203 m³/s. Costs for POL materials in both variations are similar and have been made 32.27 t ha⁻¹.

830. Investigations carried out for mulching the soil surface at the fields occupied by winter wheat and cotton showed the practical possibility to reduce the evaporation from soil surface if thickness of chuff would be increased up to 10-15 cm.

5.8 Turkmenistan: Activity 6. Effect of pigeon-pea and tree species on soil erosion of sloping lands, and creation of the field-protective strips on irrigated lands

5.8.1 Introduction

831. Field protecting forestry lines at the irrigated lands improve a micro climate, reduce wind speed, air temperature and level of Groundwater, and increase crops' productivity.

832. Pigeon peas which are cultivated in the forest plantations with drip irrigation at the mountain slopes stipulate reducing of surface flow and thereby control the processes of soil erosion. Besides this plants grow around the trees, creating the protection from fast evaporation and hot winds during summer period.

5.8.2 Objectives

833. Purpose of research is to create field protecting forestry lines for arranging micro climate and bio drainage at the irrigated sites. Fighting against water erosion of soil with a help of pigeon pea at the slope hilly sites with drip irrigation of trees plantation.

5.8.3 Materials and Methods

5.8.3.1 Study site

834. Field protecting forestry lines were created at the irrigated lands of d/c Bugdaily of Akbugday district of Akhal province. Site is located 30 km to the east from Ashgabat. Site of forest plantation with drip irrigation is used under the pigeon pea in Kopetdag foothills, located in 5 km to the south from Ashgabat in the place Berzengi.

5.8.3.2 Methodology

835. a) Works for creating field protecting forestry lines were carried out by the method of planting the transplants of wood spices (mulberry (*morus*), poplar (*populus*), maple (*aset*), acacia (*robinia*), pine (*pinus*)) which are adapted to the soil-climatic conditions of Turkmenistan. While selecting the spices their survival features were taken into account in the extreme conditions and functions which are favorably influence on the environment and crops' yield. Transplants, fertilizers and other necessary materials were bought from relevant state and private persons.

836. b) Pigeonpea planting was carried out by manual method around the trees in forest plantations with drip irrigation. Seeds in the amount of 5 kg were obtained from pigeon pea yield in 2008 at the same site.

837. C) Soil tillage for field protecting forestry lines creation and pigeon pea planting was carried out mainly by mechanized method with using tractor with mounted implement (plough, disk harrow, chisel, leveler and others), which were rented from private faces.

5.8.4 Results and discussions

5.8.4.1 Site 1. Prevention from soil erosion at the slope lands

838. Seeds of pigeon pea in 2008 were planted at the beginning of May. Germination came up after 20 May. After germination constant monitoring is carried out over the course of plants' development and observations are recorded into the journal. According to the observations on 23-25 May height of plants has been made 7-8 cm.

839. In a month by 28 June height of plants was 56-60 cm. in one month more on 28 July it was 100 cm. At the end of July flowering took place. By the end of August height of plants reached 150 cm. At the beginning of September (10-13) fruiting began and seeds were formed.

840. In summer period (June-August) irrigations (drip irrigation) was carried out as well as weeds weeding in the rows and mechanized soil tillage in the raised-beds and fertilizers application (nitrogen, super phosphate).

841. In October after seeds ripening plants were harvested for seeds collection and biomass determination.

Table 130. Pigeonpea phenological observations in 2008

	Phenological stage	Date	Quantative parameters
1.	Sowing	10.05.08	
2.	Emergence	20.05.08	
3.	Lateral branches establishment	10.06.08	2 leaves 5-6 cm
4.	Plant development	10.07.08	H= 30 cm
5.	Flowering	01.08.08	H=90 cm
6.	Fruit formation	10.09.08	H=110 cm
7.	Fruits ripening and harvesting	20.10.08	H=150 cm
8.	Cutting for biomass	15.11.08	980 kg
9.	Seed extraction (preparation)	December	5 kg
2009			
10.	Seed bed preparation	March	1000 pieces – 1.5 ha
11.	Sowing	May	1000 pieces – 1.5 ha
12.	Germination	10.06.09	2 leaves H=5-6 cm
13.	Plant and lateral branches development	30.06.09	H=25 cm

842. Plant develops mainly in height. In September height of plant has been made from 65 cm to 150 cm. Height depends on the rate of irrigation water. As more water as higher plant.

843. Number of lateral branches is 5-8 pieces; number of leaves in one plant is 60-70 pieces. Width of plant in the middle part is 45-65 cm; zone of land surface in diameter is made in average 50 cm.

844. Plants are located around the lunula with trees and cover 1m² of land. Total amount of holes with pigeon pea crop is 300 pieces; total zone of surface cover has been made 300 m² respectively.

845. In October after seeds fruiting plants were cut for biomass determination.

846. Green weight of plants has been made 980 kg. Biomass was used for feeding wild animals (Persian gazelle).

847. In 2009 pigeon pea seeds were planted in May (10-25) at the area of 1.5 ha with 1000 planting places. Before planting cleaning from weeds was carried out in the circles around stems at 1 m diameter where water comes according to the system of drip irrigation.

848. Germination came up after 10 days on 5 June. By 30 June height of plant has been made 15-20 cm and by 15 July - 35-50 cm.

5.8.4.2 Site 2. Creation of field protecting forestry lines in irrigated zone

849. Four species of trees with total number of 1000 pieces were used for planting the forestry lines. Transplants of all the types were bought. From them:

- Ash tree (Fraxinus) -500 pieces
- Mulberry tree (Morus) -200 pieces
- Poplar – (Populus) 200 pieces
- Pine-tree (Pinus eldarika) -100 pieces

850. Irrigations, raised-bed and sprinkler cleaning from weeds, fertilizers and herbicides applications were carried out in the field protecting forestry lines during summer (July - September). By 30 September acclimation rate of forestry line in average has been made 70%.

Table 131. Farming practices in 2008.

№	Farming practices	Mechanisms	Date and frequency of operations
1.	Mid season irrigations	Furrow irrigation	July-4 irrigations August-4 irrigations September-2 irrigations
2.	Harrowing, land levelling	Tractors, disk harrower and land leveller	July- 1 August – 1 September -1
3.	Weeding	Manual	July- 1 September-1
4.	Weeding using herbicides of Raundap and Gliofos	Treatment with hand-held sprayer	July- 1 September-1
5.	Fertilise application: Nitrogen, super phosphate and Urea	Manual topdressing	July- 1 August – 1 September -1
2009			
1.	Soil proceedings	Mechanical. Tractor and trailed implements (plough, disk harrowers, chisel, leveller, ditcher)	January – 1 February – 2 March – 2
2.	Tree plantation	Manual	1000 pieces
3.	Irrigations	Through furrows	April – 1 May – 1 June – 1
4.	Weeding using herbicides of Raundap – Gliofos	Treatment with hand-held sprayer	April – 1 June – 1
5.	Application of fertilizers (Urea and Nitrogen)	Manual	April – 1 Urea June – 1 N

Table 132. Trees phenological observations at forestry lines in 2008

Tree species	Planting time	Trees height (cm)				Survival rate, %
		June	July	August	September	
1. Poplar (Populus)	December 2007	100	125	160	200	80
2. Mulberry-tree (Morus)	December 2007	60	85	105	150	75
3. Ashtree (Fraxinus)	April 2008	100	120	130	150	65
4. Pine-tree (Pinus)	April 2008	120	130	140	150	75
2009						
		April	May	June		
1. Poplar (Populus)	December 2007	230	250	300		95
2. Mulberry-tree (Morus)	December 2007	150	170	200		75
3. Ashtree (Fraxinus)	April 2008	150	155	160		45
4. Pine-tree (Pinus)	April 2008	120	125	140		90
5. Maple	March 2009	75	80	90		75
6.	March 2009	80	85	90		60

851. Raised-bed plowing at the forestry lines, preparation of soils, sprinklers and furrows for the new lines with 1400 m length was carried out in autumn 2008 (October, November).

852. During 2008 seedling of thuya (Tuya) – 500 pieces and of mulberry - 500 pieces were grown in the nursery garden. These seedlings should grow in the nursery garden one year more until their height is appropriate for planting at the forestry lines.

853. In 2009 planting of forestry lines was carried in March. Totally 1000 pieces of trees were planted, including mulberry – 500 pieces, pine-tree – 250 pieces, poplar - 50 pieces, acacia – 50 pieces, maple - 150 pieces. By 30.06.2009 acclimation rate in average has been made 75%, in autumn (November-December) is planning to make additions to an initial amount, i.e. to 100%.

854. Low acclimation rate of some plants (ash-tree) is explained by cattle damages. In autumn 2009 more trees should be planted to reach 100% rate.

5.8.5 Conclusions

855. Pigeon pea seeds presented by ICARDA were planted around the planting holes for the first time in Turkmenistan in industrial conditions at the hilly foothills sites of forestry lines with drip irrigation. As a result efficiency of Pigeon pea for protection against water erosion was observed as well as reduction of physical evaporation to minimum and improvement of soil features.

856. Seeds harvesting was regulated and planting area was increased to 1.5 ha in 2009. This experiment turned out to be very effective and in future is planning to introduce it at the big areas in the zone where 30 thousand ha of forest planting were created according to the State program “Green belt”.

857. At present time the positive result for 2 years is evident at the site where was created about 3 km of forestry line, as the height of trees in average has reached 2-3 m and they have a very good effect on the field edges as in esthetical so in ecological relation. Leaders and farmers of d/c Bugdaily highly appreciate the Project’s results and plan to plant trees every year for staged creation of field protecting forestry lines at the borders of irrigated areas.

5.9 Turkmenistan: Activity 7. Calibration and use of the optical sensor Greenseeker for biomass evaluation, nitrogen management and yield prediction

5.9.1 Introduction

5.9.2 Objectives

858. Purpose of this work is the calibration of portable optical sensor in the variations of special experiment with winter wheat by measuring the normalized differential vegetation indexes. (NDVI).

5.9.3 Materials and Methods

859. The following application rates of nitrogen fertilizers were studied in the experiment.

1. 0
2. 50 kg ha⁻¹ (in reactant)
3. 100 kg ha⁻¹
4. 150 kg ha⁻¹
5. 200 kg ha⁻¹
6. 250 kg ha⁻¹

860. Winter wheat needs more nitrogen than other winter grain crops. Winter wheat yield with 25 c of grain and 60 c of chuff from 1 ha contains approximately 105 kg N, 35 kg P₂O₅ and 70 kg K₂O. In different development stages wheat consumes nitrogen and ash constituents not equally). More intensively wheat consumes the feeding element during booting and earing stages. Taking this fact into consideration, in our experiment nitrogen fertilizers as ammonium nitrate were used during the period of tillering and booting.

861. Measuring (NDVI) was carried out in accordance with the methods presented from Regional ICARDA office and constantly obtained results were sent by e-mail to a responsible expert for further processing.

5.9.3.1 Study site

862. Experiments were arranged at the irrigated territory of Akhalk scientific-experimental base NII Agriculture at the plots of 7.0 x 3.6 size. There were totally 24 plots in 6 variations of nitrogen dosage in four replications. Besides that at 8 sites farmers organized the experiments for fertilizers' dosage in two variations with 250 kg ha⁻¹ application in four replications and the variation of farmer's practice also in four replications.

5.9.4 Results and discussions

863. During first year of its development winter wheat requires more feeding elements. Needs are increase starting from tillering stage.

864. We carried out observations and measurements in order to determine the influence of different rate of nitrogen fertilizers on growth, development and productivity. Table 133 contains the observation results over winter wheat development stages. Wheat planting was carried out on 30 November 2008.

865. The given data show that applied nitrogen fertilizers do not influence on the stage of germination and tillering. Due to applying nitrogen fertilizers after these stages, they influence on the following development stages of wheat. For example, with application of 250 кг nitrogen fertilizers booting and heading stages start for 5-6 days earlier in comparison with wheat without fertilizers. At the fruiting stage on the contrary, due to the lack of feeding in the variation without nitrogen fertilizers, fruiting takes place for 2-5 days earlier in comparison with fertilized variations.

866. Before harvesting, measurements, calculations were done and fish hawk samples were taken in order to define the rates of applied nitrogen fertilizers for growth, number of spikes, number of grains in spike, weight of 1000 seeds and winter wheat productivity. Results of these observations and calculations are given in the Table 133 and Table 135.

Table 133. Growth, development and yield of winter wheat under different rates of nitrogen fertilizers

№	N rate, kg ha-1	Plant height, cm	Plant density, million plantsha-1	Number of spikes, in 1 m ²	Number of ears in spike	Weight of 100 seeds, g
1	0	49.7	3.12	327	18	28
2	50	59.6	3.15	338	22	30
3	100	71.5	3.13	344	25	32
4	150	78.7	3.11	358	30	34
5	200	86.5	3.16	367	32	36
6	250	95.2	3.08	370	34	38

867. The given data show that by increasing the rate of nitrogen fertilizers all mentioned above rates also increased. Al this made a great influence on winter wheat yield (Table 7.3).

Table 134. Effect of different rates of nitrogen fertilizers on winter wheat crop calendar

№	Rates of nitrogen fertilizers kg ha ⁻¹	Germination		Tillering		Booting		Heading		Ripeness	
		starting	full	starting	full	starting	full	starting	full	starting	full
1	0	13.12	17.12	27.01	02.02	03.02	10.03	10.04	17.04	28.05	10.06
2	50	13.12	17.12	27.01	02.02	02.03	09.03	08.04	15.04	30.05	12.06
3	100	13.12	17.12	27.01	02.02	02.03	09.03	07.04	14.04	31.05	13.06
4	150	13.12	17.12	27.01	02.02	01.02	08.03	06.04	13.04	01.06	14.06
5	200	13.12	17.12	27.01	02.02	28.02	06.03	05.04	12.04	01.06	14.06
6	250	13.12	17.12	27.01	02.02	27.02	05.03	04.04	11.04	02.06	15.06

Table 135. Yield of winter wheat influenced by nitrogen fertilizers rates (t ha⁻¹)

№	N rate kg ha ⁻¹	Replication				Total	Average
		1	2	3	4		
1	0	16.7	13.2	13.5	14.4	5.80	1.45
2	50	20.5	23.6	23.1	22.0	8.92	2.23
3	100	28.6	30.3	31.2	29.1	11.92	2.98
4	150	39.7	35.1	35.7	37.9	14.84	3.71
5	200	43.2	46.3	42.4	44.5	17.64	4.41
6	250	46.7	47.2	50.7	51.0	19.56	4.89

868. The given data show that nitrogen fertilizers make a great influence on winter wheat yield. Gradually increasing of the rates of nitrogen fertilizers from 0 to 250 kg ha⁻¹ led to the increasing of wheat yield from 14.5 c to 45.9 c from 1 ha, i.e. almost in 3.4 times.

869. Also observations were carried out over eight farm sites where nitrogen fertilizers were applied with total annual rate of 250 kg (in reactant) per one hectare and at the rest four sites fertilizers were not applied. Here wheat yield at the sites has been made (Table 136):

Table 136. Effect of N rate on wheat yield

№ sites	Rates nitrogen fertilizers, kg ha ⁻¹	№ replication	Yield, t ha ⁻¹
1	250	1	4.74
2	250	2	4.68
3	250	3	4.87
4	250	4	4.80
5	0	1	1.57
6	0	2	1.76
7	0	3	1.41
8	0	4	1.53

5.9.5 Conclusions

870. For the first time in Turkmenistan conditions research for calibration and usage of optical sensor was carried out for biomass evaluation, nitrogen controlling and yield prediction. In future this device should be used for evaluation of the influence of soil salinity level on the crops productivity. For this purpose training seminar should be arranged at the national level.

5.10 Turkmenistan :Activity 8. Evaluate the impact of laser-assisted precision land leveling on water savings, salinity and crop yields in irrigated agro-ecologies.

5.10.1 Introduction

871. The laser unit was imported and provided to national partners in early 2008. The hydraulic scrapper bucket was developed indigenously and was supplied to national program. The instruments could not be got released from the local customs until April 2008. Laser land leveling training program was organized in July again in Dashaguz. Actual field leveling work will be initiated in September to evaluate its impact on water use etc

5.10.2 Materials and Methods

872. This experiment has initiated in two regions named as Dashaguz and Akhalskyi and in Bugdaily site. In July, in Dashaguz province the laser land leveling training program was organized under support of experts from Khorezm. These activities have been conducted in irrigated territory of Dashaguz scientific - production test center of scientific research institute of cereal crops. The experimental site has an area around 2.5 hectares. The site is divided approximately on two parts where on the first part the laser land leveling has been done, and on the second part the farming practices, accepted traditionally by farmers, were applied. In late September the pre-sowing irrigation was applied at the experimental site. Thus, irrigation norm on leveled field with the laser leveler was $800 \text{ m}^3 \text{ ha}^{-1}$, while that in other field associated with traditional farming practices was in the range of $950\text{-}1000 \text{ m}^3 \text{ ha}^{-1}$. Winter wheat crop was planted at the rate of 180 kg ha^{-1} on 10th of October.

873. The second site under winter wheat crop having an area of 2 hectares have been leveled in irrigated territory of Akhalskyi scientific-experimental base of scientific research institute of Agriculture for sowing crops on permanent beds and for field with 1 ha area, where experiments were organized on calibration of Greenseeker instrument. Also the laser leveler will be used for leveling of the irrigated fields after harvesting of cotton for the organization of field experiments on optimization of irrigation norms of cotton

5.10.3 Results and discussion

874. Data for 2009 have not yet been provided.

5.11 Turkmenistan: Activity 9. Dissemination of results and developing mechanisms for up scaling and scaling out the SLMR options

875. On 7-9 July 2008 seminar was held in Dashoguz province dedicated to the laser assisted land levelling methods. 20 people participated at the seminar: khakim of Gubadag district, chairman of “Turkmenzerno” regional organization, deputy of the chairman of “Turkmenkhlopok” regional organization, farmers and specialists of Dashoguz scientific - industrial testing centre NII of Grain crops.

876. Participants of the seminar studied the method of laser equipment (preparation and installation of laser equipment and carrying out the levelling of field surface for measuring the middle point, installation of specific sensors and equipments at the scraper and observation over planner’s work). Besides this 3 more seminars were held including one final which took place before finishing the Project’s activity on 10 June 2009.

877. Project participated and demonstrated the activities with a help of two stands at the International exhibition and conference “Turkmenagro 2008” which took place on 7-9 August 2008 in Ashgabat. Project also participated at the exhibition of Turkmenistan in Tashkent in February 2009. For this purpose under the financial support of Ministry of Nature of Turkmenistan brochures were edited in three languages. This and other information is given in the Table 137.

Table 137. Dissemination of research results

№	Parameters	number
1.	workshops	4 including. 1 final
2.	Farmers field school	2
3.	Roundtable on Central TV broadcasting.	2
4.	Interview on program «Altyn Asyr».	5
5.	Interview on program «Vatan ».	3
6.	Participation at exhibition	2
7.	Leaflets and brochures were prepared and disseminated.	3

Table 138. Program of seminar on the laser leveling in Dashaguz

№	Activities	Time	Responsible persons
06.07.2008			
1.	Preliminary works (selection of venue of the workshop, hiring of the tractor, discussions of issues related to tea break and lunches for workshop participants)	09.00-18.00	Dr. Nepesov
07.07.2008			
1.	Meeting of Dr. Egamberdiev O. and tractor driver and experts from Ashgabat on the border and accommodation them in the hotel	9-30 – 12-00	Dr. Nepesov.
2.	Lunch break	12.00–14.00	
3.	Survey of laser equipment and charging of accumulators. Theoretical knowledge on application of the laser scheduler. Preparation of a tractor and a scraper for work	14.00-18.00	Dr. Nepesov. Dr. Egamberdiev O.
08.07.2008			
1.	Field works: installations of gauges and measurement of a mark of a land surface.	08.00-12.00	Dr. Egamberdiev O.
2.	Lunch break	12.00–14.00	
2.	The land leveling and testing of a scraper with the laser equipment	14.00-18.00	Dr. Egamberdiev O. Tractor driver from Khoresm
09.07.2008			
1.	Independent work of participants of the seminar come from Turkmenistan	08.00-12.00	Dr. Egamberdiev O. Dr. Agakishiev Kh Dr. Bazarov J.
2.	Lunch break	12.00-14.00	
3.	Summarizing the seminar outputs	14.00-16.00	Dr. Nepesov Dr. Egamberdiev O.
4.	Departure of Dr. Egamberdiev O. and tractor driver	16.00-18.00	Dr. Nepesov
5.	Departure of experts come from Ashgabat	18.00-22.00	Dr. Nepesov

5.12 References (Turkmenistan)

- Sapargaldiev G. Soil salinity and crops' productivity. Ashgabat. 1994.
Shakhov A.A. Salt resistance of the plants. M.: Publisher AN USSR, 19

6 Uzbekistan research report 2008-2009

6.1 Uzbek research team

Table 139. Benchmark site 32: (Sherzod Samandar Birligi /“Pakhtakor”), 33 (Esanboi-ota /“Kushmanata”), and 34 (Kyzylkum)

National Coordinator, Head of Laboratory, Central Asian Research Institute of Irrigation (SANIIRI) under Ministry of Agriculture and Water Management of the Republic of Uzbekistan	R. Ikramov
Responsible Investigator, Irrigation Specialist, SANIIRI	L. Shezdyukova
Responsible Investigator, Irrigation Specialist, SANIIRI	Dj. Narziev
Senior Scientist, Irrigation Specialist, SANIIRI	G. Basteev
Researcher, Irrigation Specialist, SANIIRI	R. Rakhimov
MSc. Student, Socio-Economist, SANIIRI	F. Yusupova
Site Coordinator, Agronomist, Uzbek Cotton Research Institute (UCRI)	Kh. Maksadov
Responsible Investigator, Irrigation Specialist, UCRI	G. Bezborodov
Responsible Investigator, Agronomist, UCRI	F. Khasanova
Senior Scientists, Agronomists, UCRI	J. Shadmanov, I. Karabaev, B. Khalikov, M. Esanbekov
Site Coordinator, Livestock Specialist, Uzbek Research Institute of Karakul Sheep Breeding and Desert Ecology (URIKSBDE)	S. Yusupov
Responsible Investigator, Agronomist, URIKSBDE	A. Rabbimov
Senior Scientists, Agronomists, URIKSBDE	T. Mukimov, B. Bekchanov
MSc student, rangelands ecology department, URIKSBDE	F. Rabbimov
Farmer and guard, URIKSBDE	O. Khudjanov
Principal Scientist, Mechanization Specialist, Uzbek Research Institute of Agricultural Mechanization and Electrification (URIAME)	R. Baimetov
Senior Scientist, Mechanical Engineer, URIAME	A. Khadjimuratov
Principal Scientist, Soil Scientist, State Soil Science and Agrochemistry Research Institute (SSSARI)	A. Tursunov
Senior Scientists, Soil Scientists, SSSARI	D. Satarov, D. Latypov
Senior Scientist, Microbiologist, Institute of Microbiology	G. Djumaniyazova
Senior Scientist, Forestry Specialist, Scientific Production Association of Ornamental Plant Industry and Forestry (SPAOPIF)	Z. Novitskiy
Researcher, Forestry Specialist, SPAOPIF	M. Sabirov

6.2 Time schedule of research activities in Uzbekistan 2007-2009

Table 140. Time schedule of research activities in Uzbekistan 2007-2009

Uzbekistan	Qr3	Qr4	Qr1	Qr2	Qr3	Qr4	Qr1	Qr2	Indicators	Outcomes
1. Assessment of soil leaching requirements in irrigated areas to enhance water productivity and reduce drainage volumes (Lysimeter and field experiment)		X	X	X	X	X	X		Reports Technologies on salinity management Afforestation technologies for diversification of saline environments Seed availability for diversification crops	Neighboring farmers practice the different technologies developed in the project to improve quality of natural resources Farmer begin custom service laser-leveling services and SMEs initiate agrobusinesses Farmers use improved crop seeds
2. Maintaining favorable soil-salinity balances in permanent raised-bed irrigated cotton-wheat systems		X	X	X	X	X	X			
3) Assessment of both native and non-native tree and grass species for their biomass productivity, salt tolerance and bio-drainage ability to rehabilitate the degraded rangelands in arid agro-ecologies		X	X	X	X	X	X			
4. Evaluation of diversified, salinity-resistant crops for enhancing biomass production for livestock in degraded rangelands			X	X	X	X	X			
5. Calibration and use of the Greenseeker for measuring crop development, comparing crop management practices and efficient nitrogen management				X	X	X	X			
6. Study the impact of laser-assisted land leveling on water saving, salt leaching, and crop performance in irrigated agro-ecologies using the EM probe and Greenseeker			X	X	X	X	X			
7. Dissemination of results and developing mechanisms for upscaling and outscaling of the SLMR options		X	X	X	X	X	X			
									Institutions use the methodologies for comparative evaluations of SLM interventions	

6.2.1 Introduction

878. In Uzbekistan the irrigated soils have low fertility level. The average value of bonitet for Uzbekistan is estimated to be 53. For the last 15 years the bonitet index has reduced by 5 or by 8.6 %.

879. One of basic elements of soil degradation is decrease in the contents of organic matter in the soils. For the last 50 years, long absence of a crop rotation with obligatory crop of lucerne in an irrigated typical sierosem soils resulted in decrease of the humus contents from 1.46 % to 0.95 % (by 30-40%) . Soils with low and very low humus content constitute about 40 %. The total area of an unproductive arable land makes up 0.5 million ha.

880. The annual soil tillage in addition to increase in the petrol charges and soil preparation expenses, also results in mixing of high fertile layer with the bottom one, which has negative effect on crop development at initial stages.

881. Traditionally applied system of the main and pre-seeding soil preparation under cultivation of the main crops, i.e. cotton and winter wheat, require the repeated passes of existing soil-cultivating machines during farm operations (because of the majority of used machines has single-operational capacity, with the passive working bodies and greater power consumption).

882. Due to repeated pass of technical equipment after soil over humidification the soil plowed and deep horizons became overconsolidated. Intensive application of chemicals in agriculture - high dozes of mineral fertilizers, pesticides, herbicides, fungicides, insecticides, defoliant, protectants of seeds resulted in large-scale negative consequences: the useful microflora of ground suppressed and the microflora destroying soil humus become more active.

883. Therefore the soil fertility enhancement is one of the main issues in agricultural ecosystem. In modern cropping pattern, the cotton crop occupies the largest area ~ 1.46 million hectares or 49.1 % of the total cultivated area. The winter cereals take the second place – 1.095 million hectares or 36.8 %. Lucerne occupies the 59.5 thousand hectares or only 2 %. Average long-term water resources discharges of the internal rivers of Uzbekistan make up 11.5 km³ year⁻¹, or about 18 % of total volume of water-requirement. Nearly 82 % of the common water-requirement (63.8 km³ year⁻¹) becomes covered due to water resources of the Transboundary Amu Darya and Syr-Darya Rivers.

884. The collector-drainage waters formed across Uzbekistan range from 20 to 23 km³. Their mineralization in upper water streams in the range of 1.5-3.0 g l⁻¹, and that in the down water streams fluctuates from 3.5-6.0 up to 5-7 g l⁻¹.

885. The irrigation water salinity has reached 1.0 – 1.1 g l⁻¹ with the small contents of organic substances on the middle rivers streams, and 2 g l⁻¹ and more (against initial 0.2 – 0.3 g l⁻¹) in the bottom river streams during the some periods which results in reduction of irrigated lands

efficiency. Efficiency of irrigation water in Uzbekistan makes up 0.05-0.08 \$US m⁻³, against 0.50-0.55 \$ US m⁻³ in the countries with advanced water-savings.

886. In general water drainage composition, 78 % of the total polluted waters caused by irrigated agriculture, 18% by the industry and 4 % by municipal services. Irrigated agriculture leads to increase the soil erosion on the sloped lands; 18-20 % of territory of Uzbekistan is subjected to water-erosion processes. The areas with depth of groundwater to 2 m make more than 50 % of the irrigated grounds.

887. The areas with a various degree of soil salinity make up more than 50 % of the irrigated lands. For 15-20 years the saline irrigated areas have increased by 0.8 million ha. Some changes occur in the ratio of the cation exchange complex in the saline soils, thus the elevated levels of magnesium and sodium in cation exchange complex of soils results in deterioration in soil physical properties and in increase of soil sodicity level. Double crops occupy only 5-7 %, and there are practically no leguminous crops in the crop rotation.

888. Use of pastures for cattle breeding without taking into account their fodder capacity leads them to digression (loss of fodder unit). Out of 22.4 million hectares of pasture area, 16.4 million ha (73 %) is subjected to digression, the fodder unit is lost by 20-30% on the area of 9.3 million ha, by 30-40% on the area of 5.0 million ha, and by more than 40% on the area of 2.1 million ha. Under this condition there are the following ways for increase efficiency of natural grassland and maintenance and therefore to maximize farmers profit in this region: rational use, development of improved range management methods and organization of fodder production under irrigation (with use artesian saline water).

6.2.1.1 Principal causes of deterioration

889. Infringement of agrotechnical requirements of cultivation of agricultural crops (system of soil preparation to sowing crop, irrigation regimes, entering of mineral fertilizers, technologies of struggle with plant pests, crop rotation - monocultures of cotton and wheat).

890. Infringements of land improvements technologies (wrong option of ameliorative actions on struggle with soil salinity, soil waterlogging because of drainage and soil leaching, irrigation parameters and irrigation technology - non-uniformity of soil moistening, infiltration, runoffs, poor land leveling).

891. In average, irrigation efficiency is estimated to be 0.64 for Uzbekistan. Capital land leveling has not been implemented in everywhere for the last 15 years, the differences in level marks, roughness make up $\pm 20-30$ cm and it is much differ from the normative ($\pm 3 \dots \pm 10$ cm). Irrigations are conducted basically through furrows and strips, because of bad land leveling of fields there is a non-uniform soil moistening, greater runoff losses. Field efficiency is 0.59-0.70. Only 30-35% water taken from irrigation source is used at the root zone of agriculture crops.

892. Water management and land amelioration objects are ageing, which lead to gradual loss of their potential and make them inappropriate for operation, under worsening water-ecological conditions. In order to maintain those in an efficient operating condition it is required significant financial and material resources investments.

893. On-site inspections of a technical condition of the closed horizontal drainage have shown that they badly operate on greater areas. Because of ageing and deterioration of supply by material resources the volumes of water pumping through vertical pumps have decreased. However, last years because of economic and financial difficulties the repair work are conducted not up to the mark.

894. Ways of sustainable land management in Uzbekistan through transition from the traditional intensive agriculture technologies to resource saving land husbandry technologies will deliver positive influence on food supply and livelihood and also on soil quality, water resources and ecologies in order to provide sustainable soil desalinization and enrichment of the soil fertility.

895. Transition to integrated water resources management (IWRM), as the process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems, enhance the natural fodder yields productivity and maintain it through rational use, development of improved range management methods and organization of fodder production under irrigation (with use artesian saline water), reusing of low quality wastewater for crop irrigation and soil leaching, utilization it through cascade using and halophyte production, advanced reforms in agriculture and water management, transition towards water payments and water resources contamination.

6.3 Uzbekistan: Activity 1. Assessment of soil leaching requirements in irrigated plains to enhance water productivity and reduce drainage volumes in cotton-wheat system (Lysimeter and field experiment)

6.3.1 Objective

896. The aim of the research program was to study integration of soil leaching and water saving technology to reduce field-level water input without decreasing the productivity of the cotton-wheat system.

6.3.2 Materials and Methods

6.3.2.1 Site description

897. Research were conducted in Sherzod Samandar Birligi farm located in Sardoba district of Syr-Darya province and located at the boundary of the proluvial-alluvial zones of Hungry steppe within the medium stream of Syr-Darya river. The general view of the experimental arrangements is given in Figure 106.

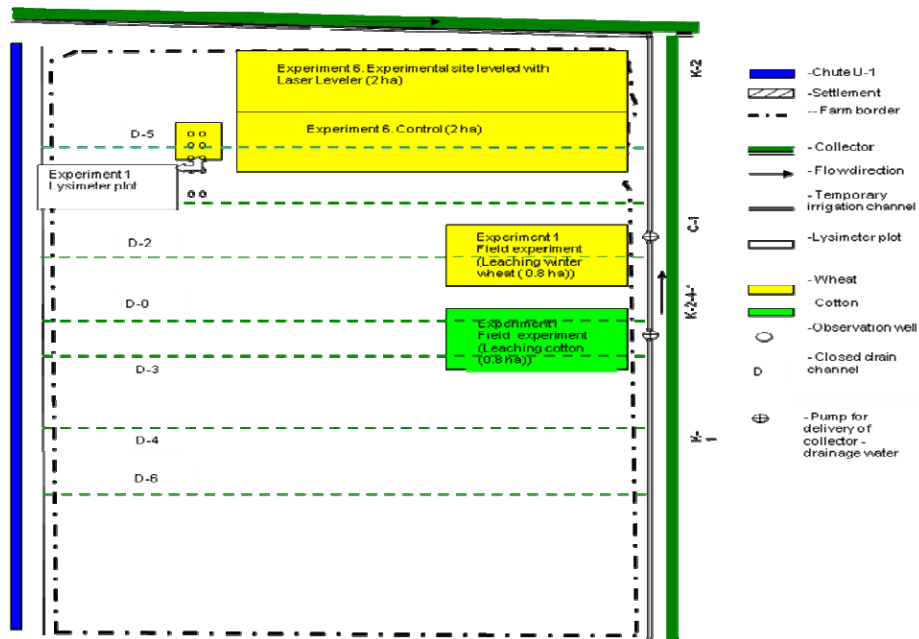


Figure 106. Schematic plan of the Syr-Darya site

6.3.2.2 Climate

898. Features of the climate are the hot, dry summer, dry warm autumn, low-snowing winter with unstable weather and wet rainy spring. Mid-annual air temperature is +15^oC, the coldest months in a year - December and January with an absolute minimum-28^oC. The hottest months are June, July and August with monthly average air temperature of +26.29^oC and absolute maximum temperature of +48^oC. The annual amount of precipitations makes up 270-290 mm which falls extremely non-uniformly within a year, mainly during November-May.

6.3.2.3 Soils

899. The territory of the site is composed by thickmass (more than 300 m) of clay deposits of Quaternary age (sandy loam, loams, clay) at places with lenses of sand.

900. Soil texture of experimental site is presented basically by sandy loams. The soil texture down in the profile becomes loamy light sands (70-120 cm). Hydromeliorative system in this zone presented by modern type of irrigation-drainage system and constructions on it and representative for the area nearly 1 million ha in main part of South zone of Hungry and Jizzakh steppe.

901. There were not significant deviations in groundwater level because of the small size of experimental site. Groundwater level determined at the range 103-169 cm, which resulted by low leaching efficiency of drainage system. Groundwater is classified mostly as a sulphatic on chemical characteristics, rarely sulphate-chloride with TDS of 5.3-5.5 g l⁻¹ and Chloride concentration of 0.4-0.9 g l⁻¹.

902. According to the soil humus and phosphorous content, the soil could be classified as poor and very poor.

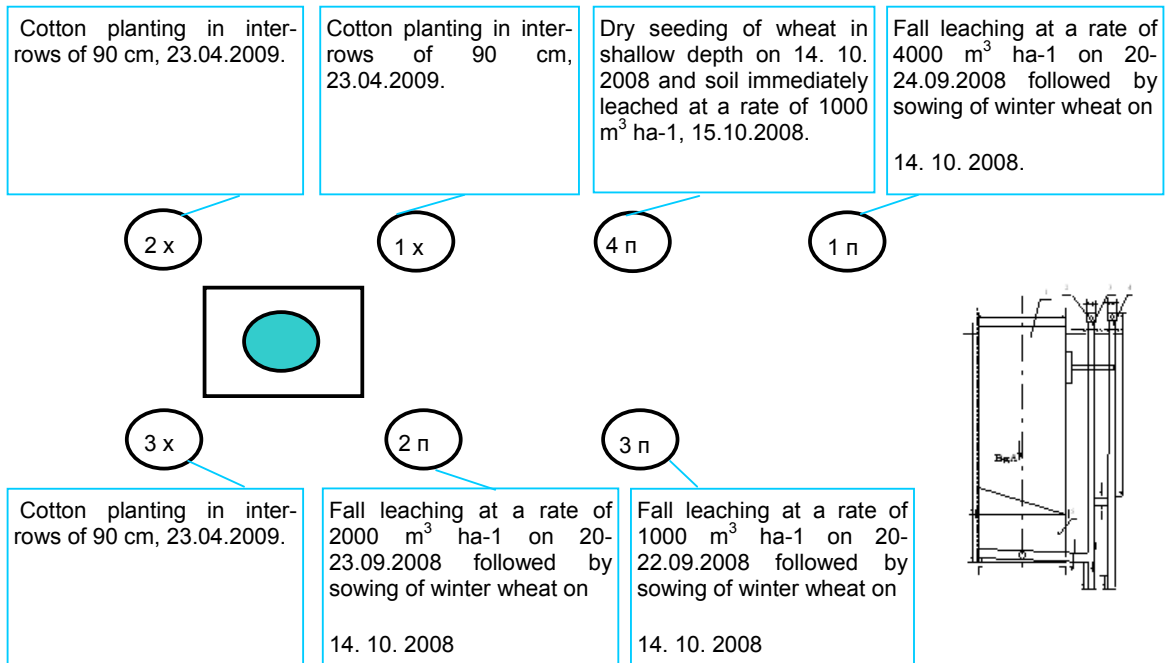


Figure 107. Experimental layout of lysimetric treatments in Sherzod Samandar Birligi farm in Syrdarya province

903. Lysimeter and field study Research were conducted in the Sherzod Samandar Birligi farm situated in Sardoba district of Syrdarya province. Both sites were located at the distance of 15-20 meters from each other, therefore the soil-climatic conditions for two sites were identical. The scheme and photo of lysimeter site is presented in Figure 107 and Figure 108.



Figure 108. General view of lysimeter experiment

6.3.2.4 Salinity measurements

904. Saline groundwater table ($EC_w \sim 3-4 \text{ dS m}^{-1}$) in lysimeters was maintained at a depth of $105 \pm 5 \text{ cm}$ during crop season. EC meter (model: Progress 1T) was used to determine the soil salinity level. Groundwater salinity was measured by EC meter (model: Ex-Express T). The soil moisture was observed by Irrrometer (Figure 109).



Figure 109. Using express methods for monitoring the soil salinity and soil moisture.

905. The experimental layout of field experiment on soil leaching for winter wheat crop planted in 2007-2008 is presented in Figure 110. Due to eating of crops by cows, hens, the experiment have been shifted to another side of the same field. The experimental layout of experiment in 2008-2009 is shown in Figure 111.

906. Experiment on pre-sowing leaching for winter wheat was conducted in 2 replications, while that for cotton was conducted in 4 replications. The experimental layout of cotton experiment in 2008-2009 is shown in Figure 112.

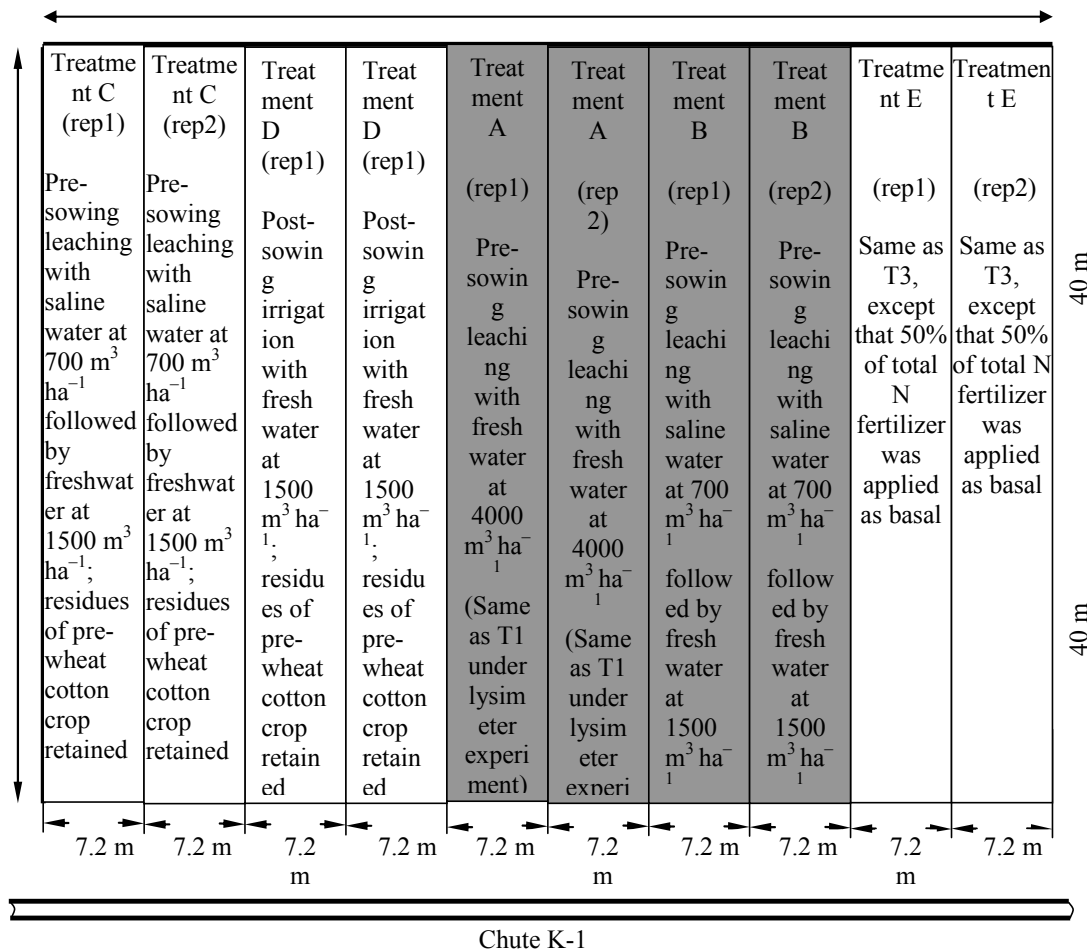


Figure 110. Experimental layout of field experiment with leaching trials tested for winter wheat crop in 2007-2008

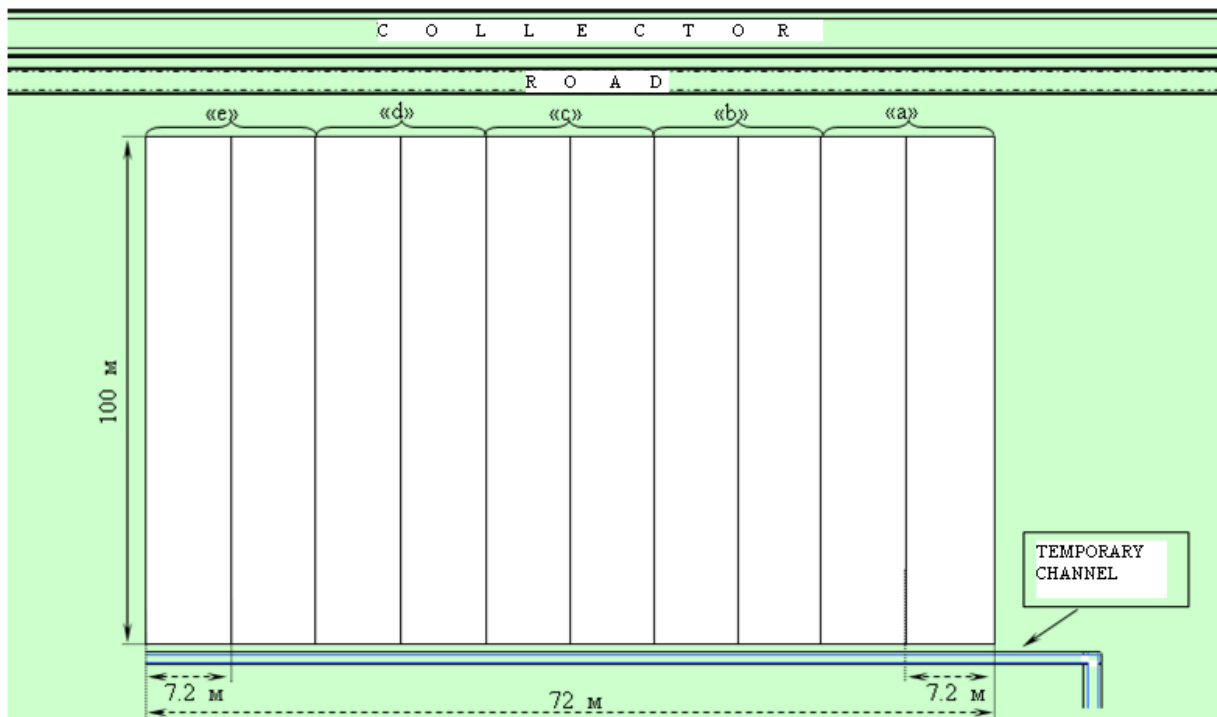


Figure 111. Experimental layout of field experiment with leaching trials tested for winter wheat crop in 2008-2009

907. Treatment for winter wheat planted in 2007-2008 has comprised the following:

- (a) Saline plowed field with all residues removed, pre-sowing leaching with fresh water at the rate of $4000 \text{ m}^3 \text{ ha}^{-1}$ and plant as usual to the soil depth of 5-6 cm.
- (b) Saline plowed field with all residues removed, Pre-sowing leaching with saline water at $700 \text{ m}^3 \text{ ha}^{-1}$ to improve the antecedent soil moisture followed by freshwater at $1500 \text{ m}^3 \text{ ha}^{-1}$ and plant as usual to the soil depth of 5-6 cm
- (c) Saline undisturbed field with all residues retained on the surface, Pre-sowing leaching with saline water at $700 \text{ m}^3 \text{ ha}^{-1}$ to improve the antecedent soil moisture followed by freshwater at $1500 \text{ m}^3 \text{ ha}^{-1}$ and plant as usual to the soil depth of 5-6 cm
- (d) Saline undisturbed field with all residues retained on the surface, plant to the soil depth of 2.5-3.0 cm and post-sowing leaching with fresh water at $1500 \text{ m}^3 \text{ ha}^{-1}$. Fertilizers will be used as per local practice (all N after sowing).
- (e) Saline undisturbed field with all residues retained on the surface, plant to the soil depth of 2.5-3.0 cm and post-sowing leaching with fresh water at $1500 \text{ m}^3 \text{ ha}^{-1}$. 50% N and other fertilizers will be applied before pre-sowing irrigation to compare with Treatment (d).

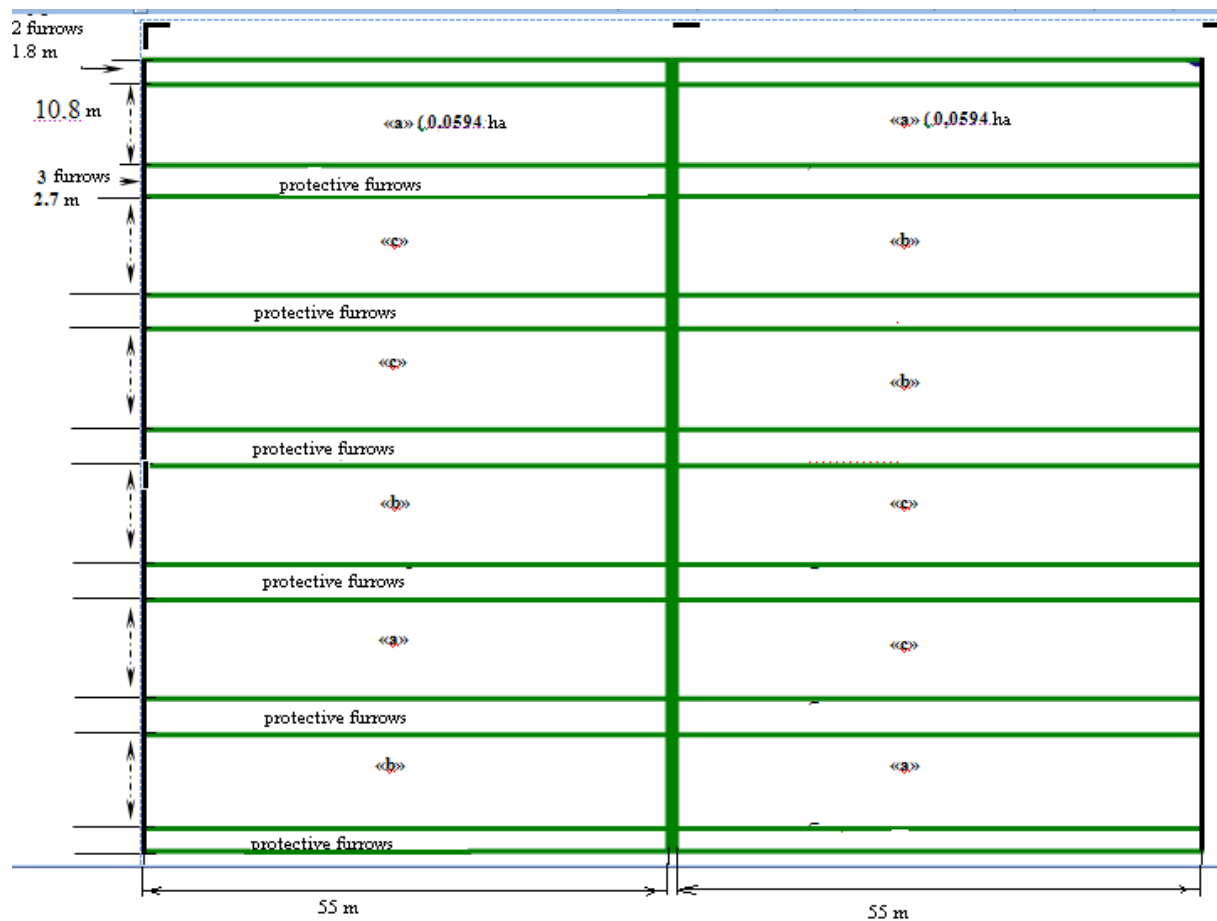


Figure 112. Experimental layout of field experiment with leaching trials tested for cotton crop in 2008-2009

908. Treatment for cotton planting has comprised the following:

- (a) Saline plowed field with all residues removed, pre-sowing leaching with fresh water at the rate of $4000 \text{ m}^3 \text{ ha}^{-1}$ and plant as usual.
- (b) Saline plowed field with all residues removed, pre-sowing leaching with saline water at $700 \text{ m}^3 \text{ ha}^{-1}$ to improve the antecedent soil moisture, followed by freshwater at $1500 \text{ m}^3 \text{ ha}^{-1}$ and plant as usual to the soil depth of 5-6 cm.
- (c) Saline undisturbed field with all residues removed, plant to the soil depth of 2.5-3.0 cm and post-sowing leaching with fresh water at $1500 \text{ m}^3 \text{ ha}^{-1}$

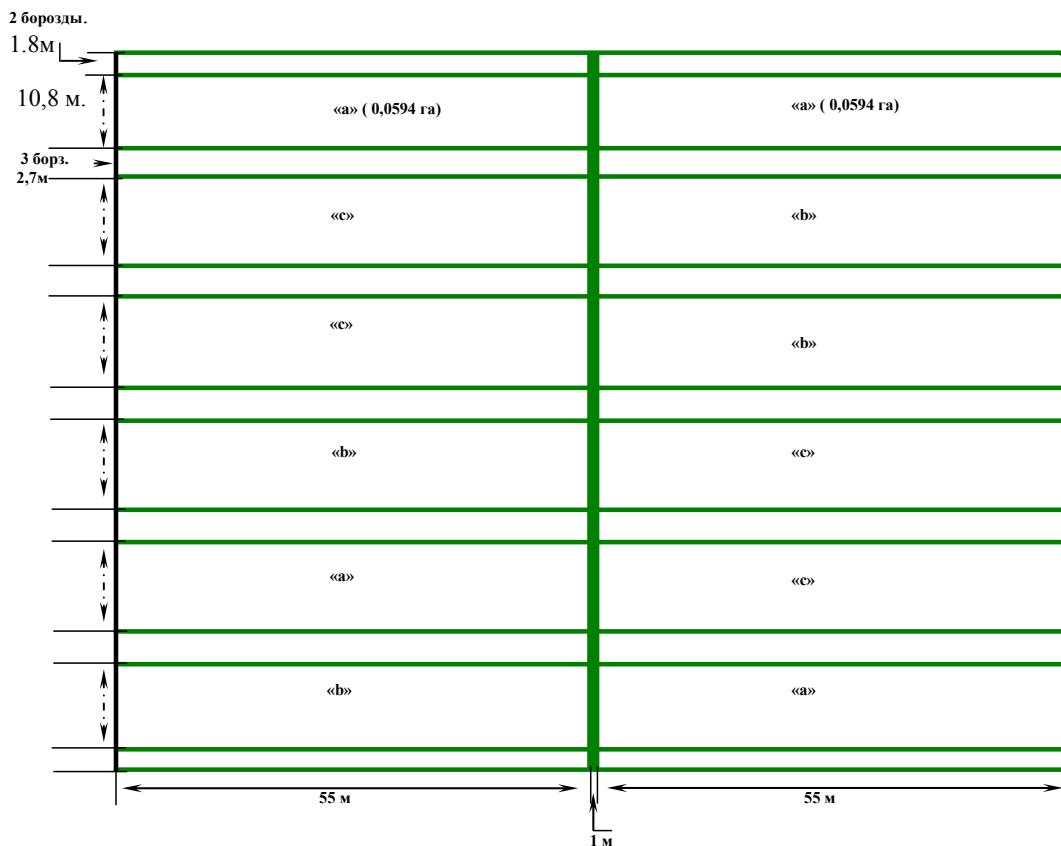


Figure 113. Experimental lay-out

6.3.3 Results of the lysimeter experiments

909. The soil was salinized by irrigation with drainage water (EC_{dw} was 3.4 dS m^{-1}) at the starting of the experiment (August 2007). Groundwater level was maintained at a depth of $105 \pm 5 \text{ cm}$ during crop season. It was main condition of the technical task in order to evaluate the possibilities to construct shallow drainage as an alternative to the existing deep ($h = 2.5\text{-}3.2 \text{ m}$) drainage system in Central Asian countries.

910. It may be mentioned that more efficient soil and groundwater desalinization was observed for applications of $4000 \text{ m}^3 \text{ ha}^{-1}$ water to the moderately and highly saline soils under appropriate drainage conditions created in lysimeters. During winter wheat crop season the soil leaching with heavier rate ($4000 \text{ m}^3 \text{ ha}^{-1}$) maintained the soil salinity level below 4 mS cm^{-1} (low saline - FAO classification) (Table 141, Table 142) while soil salinity ranged from 3.84 to 4.7 mS cm^{-1} when leaching at the rate of $2000 \text{ m}^3 \text{ ha}^{-1}$. Soil leaching at the rate of $1000 \text{ m}^3 \text{ ha}^{-1}$ applied before and after sowing has lead to larger soil salinity ($6\text{-}8 \text{ mS cm}^{-1}$). However soil salinity increase did not affect winter wheat crop yield. According to the data presented in the Table 143, wheat leaching accomplished by a slightly heavier pre- or post sowing irrigation at the rate of $1000 \text{ m}^3 \text{ ha}^{-1}$ did not affect also on nutrient status of the soil as in the period between

irrigation events the leached N returned back with groundwater capillary rise to the soil root zone. Thus, under shallow groundwater level (100-110 cm) and under good drainage conditions in the Hungry steppe, the leaching rates could be reduced down to $1000\text{ m}^3\text{ ha}^{-1}$, instead of traditionally applied $4000\text{ m}^3\text{ ha}^{-1}$ and irrigation rates could be reduced to $440\text{ m}^3\text{ ha}^{-1}$ vs. $700\text{--}1500\text{ m}^3\text{ ha}^{-1}$ (traditional rate). In such case, drainage volume was $1068.3\text{--}1367.6\text{ m}^3\text{ ha}^{-1}$ against $4367.6\text{ m}^3\text{ ha}^{-1}$ (Table 144)

Table 141. Soil salinity dynamics at different treatments in lysimeters with winter wheat planted, 2007-2008

Methods of salinity determination		Treatment 1, $4000\text{ m}^3\text{ ha}^{-1}$	Treatment 2, $2000\text{ m}^3\text{ ha}^{-1}$	Treatment 3, $1000\text{ m}^3\text{ ha}^{-1}$	Treatment 4, post-sowing $1000\text{ m}^3\text{ ha}^{-1}$
Dry residue	Soil salinity before leaching, 04.10.2007, %	0.632	0.755	0.727	0.765
HCO ₃		0.022	0.024	0.2	0.026
CL	Soil salinity before leaching, 04.10.2007, %	0.036	0.177	0.216	0.033
SO ₄		0.31	0.44	0.36	0.34
Dry residue	Soil salinity before leaching, 04.10.2007, %	0.562	0.888	0.552	0.557
HCO ₃		0.022	0.024	0.027	0.025
CL		0.036	0.036	0.031	0.032
SO ₄		0.31	0.5	0.27	0.22
Soil salinity before leaching, 04.10.2007, %		6,73	14.38	9.66	6.00
After leaching 18.10.2007, %		4,71	5.63	6.17	4.68
Soil salinity before leaching, 04.10.2007, %		6,54	5.83	6.2	5.71
After leaching 18.10.2007, %		7.31	5.43	6.88	5.34
Soil salinity before leaching, 04.10.2007, %		6.3	5.15	6.2	5.22
Soil salinity before leaching, 04.10.2007, %		6.83	5.77	5.64	7.50

Table 142. Soil salinity dynamics at different treatments in lysimeters with winter wheat planted, 2008-2009

Methods of salinity determination	Treatment 1, 4000 m ³ ha ⁻¹	Treatment 2, 2000 m ³ ha ⁻¹	Treatment 3, 1000 m ³ ha ⁻¹	Treatment 4, post-sowing 1000 m ³ ha ⁻¹
“Progress 1T” mS m ⁻¹ , Before leaching 29.09.2008	6.90	5.20	6.38	7.80
“Progress 1T” dS m ⁻¹ , After leaching 14.10.2008	2.11	3.84	4.81	5.18
“Progress 1T” dS m ⁻¹ , 12.11.2008	3.59	4.03	5.72	5.93
“Progress 1T” dS m ⁻¹ , 20.11.2008	3.69	4.4	6.13	7.69
“Progress 1T” dS m ⁻¹ , 11.12.2008	3.80	4.57	6.91	7.06
“Progress 1T” dS m ⁻¹ , 18.02.2008	3.60	4.04	6.09	7.68
“Progress 1T” dS m ⁻¹ , 3.04.2008	3.50	4.01	5.95	6.62
“Progress 1T” dS m ⁻¹ , 17.04.2008	3.50	4.02	6.01	6.92
“Progress 1T” dS m ⁻¹ , 30.04.2008	3.30	3.90	5.75	5.77
“Progress 1T” dS m ⁻¹ , 06.06.2008	3.70	4.70	7.10	8.05

Table 143. Nutrient elements dynamics on lysimeters at different treatments with winter wheat planted crop

Soil fertility attributes		Treatment 1, 4000 m ³ ha ⁻¹	Treatment 2, 2000 m ³ ha ⁻¹	Treatment 3, 1000 m ³ ha ⁻¹	Treatment 4, post-sowing 1000 m ³ ha ⁻¹
Humus, % before leaching (04.10.07)		0.95	0.54	0.49	0.88
Soil N, P, K content before leaching, mg kg ⁻¹	P ₂ O ₅	22.5	18.5	17.5	19
	K ₂ O	181	206.5	213	199.5
	N-NO ₃	47.9	27	35.5	43.7
Soil N, P, K content after leaching, mg kg ⁻¹ (18 Oct)	P ₂ O ₅	7.9	10.7	10.97	18
	K ₂ O	180	315	174	288.3
	N-NO ₃	36.8	56.4	48.5	43.9
Soil N, P, K content before leaching, mg kg ⁻¹ (4 Oct 2008)	P ₂ O ₅	7.9	10.7	10.97	18
	K ₂ O	180	315	174	288.3
	N-NO ₃	36.8	56.4	48.5	43.9
Soil N, P, K content after soil leaching, mg kg ⁻¹ (16 June 2009)	P ₂ O ₅	36.05	38.9	25.75	23.9
	K ₂ O	290	301	253	237
	N-NO ₃	0.08	0.09	0.079	0.066
	Humus, %	1.24	1.32	1.03	0.94

Table 144. Water balances in lysimeters with winter wheat planted crop

Water balance elements, m ³ ha ⁻¹	Treatment 1, 4000 m ³ ha ⁻¹	Treatment 2, 2000 m ³ ha ⁻¹	Treatment 3, 1000 m ³ ha ⁻¹	Treatment 4, post-sowing 1000 m ³ ha ⁻¹
2007-2008				
Total applied water, m ³ ha ⁻¹	4440	2320	1280	1335
Rainfall, m ³ ha ⁻¹	2303	2303	2303	2303
Groundwater contribution, m ³ ha ⁻¹	3300	3200	3100	3400
Total Income, m ³ ha ⁻¹	10043	7823	6683	7038
Evaporation +transpiration, m ³ ha ⁻¹	6443	6363	6133	6488
Drainage, m ³ ha ⁻¹	3600	1460	550	550
Expenditure, m ³ ha ⁻¹	10043	7823	6683	7038
2008-2009				
Water balance elements, m ³ ha ⁻¹	Treatment 1, 4000 m ³ ha ⁻¹	Treatment 2, 2000 m ³ ha ⁻¹	Treatment 3, 1000 m ³ ha ⁻¹	Treatment 4, post-sowing 1000 m ³ ha ⁻¹
Total applied water, m ³ ha ⁻¹	4200	2200	1200	
Rainfall, m ³ ha ⁻¹	3693	3693	3693	3693
Groundwater contribution, m ³ ha ⁻¹	3712.5	3712.5	3712.5	3797.8
Total Income, m ³ ha ⁻¹	11605.5	9605.5	8605.5	8490.8
Evaporation +transpiration, m ³ ha ⁻¹	7237.9	7237.9	7237.9	7237.9
Drainage, m ³ ha ⁻¹	4367.6	2367.6	1367.6	1252.9
Expenditure, m ³ ha ⁻¹	11605.5	9605.5	8605.5	8490.8

911. Comparison of different soil leaching treatments under maintaining the groundwater level at 1.00 m constant level revealed that the most profitable options were the pre-sowing soil leaching at the rate of 1000 m³ ha⁻¹ (Treatments 3) (crop yield was 6.4 t ha⁻¹ in 2008) under usual planting at the depth of 5.0-6.0 cm and the post-sowing irrigation at the rate of 1000 m³ ha⁻¹ (Treatment 4), following the sowing of winter wheat at shallow 2.5-3.0 cm soil depth (crop yield was 5.9 t ha⁻¹ in 2008) which allows to save up to 3200 m³ ha⁻¹ of freshwater without any reduction in the water and land productivity. Similar relatively higher yields under those treatments were observed in 2009. Water productivity was also maximum under Treatments 3 and 4 (0.68-0.84 kg m⁻³) against traditional technology (0.48-0.77 kg m⁻³) (Table 145, Figure 114).



Figure 114. Lysimeters planted with winter wheat and cotton.

Table 145. Winter wheat yield and water productivity in lysimeters under different soil leaching treatments

Parameters	Treatment 1, 4000 m ³ ha ⁻¹	Treatment 2, 2000 m ³ ha ⁻¹	Treatment 3, 1000 m ³ ha ⁻¹	Treatment 4, post-sowing 1000 m ³ ha ⁻¹
2007-2008				
Yield, kg ha ⁻¹	5900	6000	6400	5900
Gross productivity, kg m ⁻³	0.49	0.61	0.72	0.67
Water productivity, kg m ⁻³	0.77	0.78	0.84	0.77
2008-2009				
Yields, kg ha ⁻¹	5610	5930	5880	5850
Gross productivity, kg m ⁻³	0.48	0.62	0.68	0.69
Water productivity, kg m ⁻³	0.78	0.82	0.81	0.81

6.3.4 Results of the field experiments

912. For the monitoring period, during the winter wheat crop season groundwater level was in the range of 103 - 169 cm, which was resulted by poor working capacity of drainage system (Table 146, Table 147).

913. Dynamics of soil salinity at various variants of leaching and cultivation of winter wheat in a Sherzod Samandar Birligi farm in Syr-Darya province is presented in Table 148 and Table 149.

Table 146. Groundwater level (GWL) dynamics under different soil leaching treatments applied for winter wheat crop in Sherzod-Samandar Birligi farm in Syrdarya province

Treatments									
(a)		(b)		(c)		(d)		(e)	
Date	GWL, cm	Date	GWL, cm	Date	GWL, cm	Date	GWL, cm	Date	GWL, cm
XI 2007	236	XI 2007	238	XI 2007	237	XI 2007	237	XI 2007	241
XII 2007	138	XII 2007	139	XII 2007	136	XII 2007	137	XII 2007	146
I.2008	139	I.2008	139	I.2008	139	I.2008	140	I.2008	139
II.2008	110	II.2008	143	II.2008	148	II.2008	148	II.2008	140
III.2008	103	III.2008	103	III.2008	112	III.2008	109	III.2008	101
IV.2008	106	IV.2008	107	IV.2008	111	IV.2008	111	IV.2008	101
V.2008	170	V.2008	169	V.2008	167	V.2008	169	V.2008	136

Table 147. Groundwater level (GWL) dynamics under different soil leaching treatments applied for winter wheat crop in Sherzod-Samandar Birligi farm in Syrdarya province

Treatments									
(a)		(b)		(c)		(d)		(e)	
Date	GWL, cm	Date	GWL, cm	Date	GWL, cm	Date	GWL, cm	Date	GWL, cm
XI 2008	197	XI 2008	204	XI 2008	215	XI 2008	216	XI 2008	215
XII 2008	187	XII 2008	194	XII 2008	213	XII 2008	213	XII 2008	214
I.2009	190	I.2009	192	I.2009	194	I.2009	194	I.2009	194
II.2009	191	II.2009	189	II.2009	189	II.2009	189	II.2009	193
III.2009	156	III.2009	163	III.2009	187	III.2009	187	III.2009	183
IV.2009	148	IV.2009	152	IV.2009	150	IV.2009	152	IV.2009	142
V.2009	132	V.2009	128	V.2009	126	V.2009	121	V.2009	125
VI.2009	184	VI.2009	185	VI.2009	185	VI.2009	177	VI.2009	179

Table 148. Soil salinity dynamics under different soil leaching and winter wheat sowing technologies in Sherzod-Samandar Birligi farm, Syrdarya province, 2007-2008

№	Soil salinity determination methods	Treatments				
		(a)	(b)	(c)	(d)	(e)
1	TDS before leaching, %.	1.57 (04.10.07)	1.57 (04.10.07)	1.57 (04.10.07)	1.57 (04.10.07)	1.57 (04.10.07)
2	EC meter "Ex-Express T" before leaching mS/m.	78.7 (13.09.07)	78.7 (13.09.07)	78.7 (13.09.07)	78.7 (13.09.07)	78.7 (13.09.07)
3	TDS after leaching, %. (26.11.07)	1.40	0.879	1.459	1.5	1.25
4	EC meter "Ex-Express T" before leaching mS/m.	93 (08.03.2008)	70 (08.03.2008)	115 (08.03.2008)	89 (08.03.2008)	78 (08.03.2008)
5	EM-38 RT (soil depth of 150 cm) mS m ⁻¹ .	86 (08.03.2008)	69 (08.03.2008)	107 (08.03.2008)	91 (08.03.2008)	74 (08.03.2008)
6	EC meter "Ex-Express T" mS m ⁻¹	83 (13.04.2008)	22 (13.04.2008)	86 (13.04.2008)	91 (13.04.2008)	53 (13.04.2008)
7	EM-38 RT (soil depth of 150 cm) mS m ⁻¹ .	130 (18.04.2008)	109 (18.04.2008)	133 (18.04.2008)	128 (18.04.2008)	20 (18.04.2008)
8	EM-38 RT (soil depth of 75 cm) mS m ⁻¹ .	99 (18.04.2008)	82 (18.04.2008)	109 (18.04.2008)	105 (18.04.2008)	95 (18.04.2008)
9	EM-38 RT (soil depth of 150 cm) mS m ⁻¹ .	122 (14.05.2008)	122 (14.05.2008)	135 (14.05.2008)	128 (14.05.2008)	88 (14.05.2008)
10	EM-38 RT (soil depth of 75 cm) mS m ⁻¹ .	82 (14.05.2008)	81 (14.05.2008)	101 (14.05.2008)	96 (14.05.2008)	49 (14.05.2008)

Table 149. Soil salinity dynamics under different soil leaching treatments and winter wheat sowing technologies in Sherzod-Samandar Birligi farm in Syrdarya province, 2008-2009

№	Soil salinity determination methods	Treatments				
		(a)	(b)	(c)	(d)	(e)
1	EC meter "Ex-Express T" before leaching mS m ⁻¹ .	7.5 (01.08.08)	4.56 (01.08.08)	5.36 (01.08.08)	8.12 (01.08.08)	5.01 (01.08.08)
2	EC meter "Ex-Express T" after leaching mS m ⁻¹ .	4.04 (13.09.08)	5.94 (13.09.08)	6.67 (13.09.08)	6.15 (13.09.08)	7.34 (13.09.08)
3	EM-38 RT (soil depth of 75 cm) mS m ⁻¹	3.6 (26.05.09)	3.3 (08.03.08)	3.0 (08.03.08)	4.04 (08.03.08)	5.05 (08.03.08)

914. According to the soil humus and phosphorous content, the soils could be classified as poor and very poor, respectively. Because of relatively shallow groundwater level, bad work of a drainage system, the nutrients were not removed out of farmer holding and through upward movement of groundwater in inter-irrigation period via capillary rise they returned back to the root zone (Table 150; Table 151, Figure 115).

915. In low-water season 2007-2008, total water application rate for winter wheat was 4627 m³ ha⁻¹ (treatment a), while it was 3103 m³ ha⁻¹ under leaching rate of 1000 m³ ha⁻¹ ("d" and "e"). Because of the breakage of the pump no drainage water was applied from collector. In 2008-2009 the total irrigation rate in a treatment "a" was 6820 m³ ha⁻¹, while that in treatments "d" and "e" was minimal 3910 m³ ha⁻¹ (Table 152; Table 153). Drainage water (EC_{dw} 5-6 dS m⁻¹) was applied in treatments «b» and «c».

Table 150. Concentration of Nutrient elements in the soil under different soil leaching technologies and winter wheat growing at Sherzod Samandar Birligi farm in Syrdarya province

Attributes	Soil leaching treatments					
	(a)	(b)	(c)	(d)	(e)	
Humus, %. Before leaching (04.10.07)	0.61	0.61	0.61	0.61	0.61	
Amount of N-NO ₃ in mobile forms before leaching, mg kg ⁻¹ (04.10.2007).	34.35	34.35	34.35	34.35	34.35	
Amount of N, P, K in the soil after soil leaching (18.10.2007).	P ₂ O ₅	7.3	10.4	13.6	7.4	17.8
	K ₂ O	368.	551	247	132	427
	N-NO ₃	40.4	27.5	43.1	50.1	56.2
NDVI measurements taken by Greenseeker (18.04.2008)	0.877	0.837	0.769	0.811	0.888	

Table 151. NPK composition in the soils, 2008-2009

Attributes		Soil leaching treatments				
		(a)	(b)	(c)	(d)	(e)
Amount of N, P, K in the soils (23.09.2008).	P ₂ O ₅	10.85	10.85	10.85	10.85	10.85
	K ₂ O	216.7	216.7	216.7	216.7	216.7
	N.%	0.053	0.053	0.053	0.053	0.053
Amount of N, P, K in the soils (16.06.2009).	Humus, %	0.49	0.54	0.75	0.57	0.39
	P ₂ O ₅	17.45	11.75	14.87	14.2	23.2
	K ₂ O	230.5	211	255	252	239
	N %	0.049	0.056	0.075	0.045	0.055

**Figure 115. Different pre-sowing soil leaching practices applied for winter wheat and cotton**

916. Salts leached out of the plant root zone by light soil leaching and irrigations, and atmospheric precipitation during winter and spring season have maintained low salinity level in soil solution, which led to higher winter wheat yield, less saline groundwater level and reduced the drainage volumes substantially. Post-sowing irrigations assisted in soil moisture accumulation, salt leaching and desalinization of the upper root zone and good seed germination.

917. In field experiments, the highest crop yields (4.4-4.6 t ha⁻¹) were observed at treatments “c”, “d”, “e” without soil tillage and with plant residues in moderately and high saline soils (Figure 116). The water productivity was also higher (0.81-0.95 kg m⁻³) under those treatments (Table 154).

Table 152. Water application rates applied for winter wheat crop at Sherzod Samandar Birligi farm in Syrdarya province, 2007-2008

Parameters	Treatments				
	(a)	(b)	(c)	(d)	(e)
Soil leaching rates, m ³ ha ⁻¹	4000	1500	1500	1500	
	30.09.2007	04.10.2007	07.10.2007	07.10.2007	
Pre-sowing irrigation, 08-12.12.07.					1500
1 st irrigation, m ³ ha ⁻¹	242 (24.10.07)	370 (24.10.07)	(08-325) (24.11.07)	(08-960) (12.11.07)	(08-960) (12.11.07)
2 nd irrigation, m ³ ha ⁻¹ 23.03.08.	385	735	630	643	643
Total, m ³ ha ⁻¹	4627	2605	2455	3103	3103

Table 153. Water application rates applied for winter wheat crop at Sherzod Samandar Birligi farm in Syrdarya province, 2008-2009

Parameters	Treatments				
	(a)	(b)	(c)	(d)	(e)
Soil leaching rates, m ³ ha ⁻¹	4000	2200	2200		
	18.09.2008	17.09.2008	17.09.2008		
Pre-sowing irrigation, 18.10.08.				1500	1500
1 st irrigation, m ³ ha ⁻¹	720 (20.10.08)	720 (20.10.08)	690 (20.10.08)		
2 nd irrigation, m ³ ha ⁻¹	680 (18.02.09)	650 (18.02.09)	630 (18.02.09)	800 (18.02.09)	800 (18.02.09)
3 rd irrigation, m ³ ha ⁻¹	670 (6.03.09)	650 (6.03.09)	620 (6.03.09)	790 (6.03.09)	790 (6.03.09)
4 th irrigation, m ³ ha ⁻¹	750 (8.04.09)	740 (8.04.09)	720 (8.04.09)	820 (8.04.09)	820 (8.04.09)
Total, m ³ ha ⁻¹	6820	4960	4860	3910	3910



Figure 116. Growth and development of winter wheat and cotton on leached soils

918. Thus, the 2-year field experiments have revealed, that technology of *pre*-sowing soil leaching at the rate of $1500 \text{ m}^3 \text{ ha}^{-1}$ with zero-tillage followed by shallow winter wheat sowing with keeping the plant residues was most effective in comparison with traditional soil leaching technology for cultivation of winter wheat crop. Another efficient technology was *post*-sowing soil leaching at the rate of $1500 \text{ m}^3 \text{ ha}^{-1}$ followed sowing of winter wheat with zero-till planter.

919. In 2009 the following soil leaching treatments were established for cotton cultivation: (1) control – *pre*-sowing soil leaching at the rate of $4000 \text{ m}^3 \text{ ha}^{-1}$ on tilled field, (2) *pre*-sowing soil leaching with $700 \text{ m}^3 \text{ ha}^{-1}$ saline water followed by $1500 \text{ m}^3 \text{ ha}^{-1}$ freshwater and (3) *post*-sowing soil leaching at the rate of $1500 \text{ m}^3 \text{ ha}^{-1}$. In an effort to combine the soil leaching and *pre*-sowing irrigation to save water resources and to reduce the labor costs, the soil leaching schedule was shifted from traditional applied period - January and early February to the beginning of early spring season (28 February). However spring months (March, April, and May) were much rainy and no irrigation was applied after cotton sowing. In spite of this fact there were not significant differences in cotton growth and development over all treatments.

920. Thus, the organization of leaching of cotton with the maximal shift of leaching schedule to the spring combining leaching with *pre*-sowing irrigation, has allowed saving of one irrigation.

Table 154. Agro economical parameters of winter wheat crop sown with the use of different soil leaching treatments at the Sherzod Samandar birligi experimental site

№		(a)	(b)	(c)	(d)	(e)
2007-2008						
1.	Net profit, \$	-39	174	31	41	10
2.	Total variable costs, \$	1053	1143	1092	1018	1095
3.	Gross productivity, kg m ⁻³	0.61	1.03	0.95	0.81	0.84
4.	Gross productivity, UZS/1000m ³		33243	8362	10041	2449
5.	Gross productivity, \$/1000 m ³		5.2	9.7	13.2	2.6
6.	Gross productivity WP, kg/m ³	0.62	1.03	0.95	0.81	0.84
7.	Water productivity, (yield/ET total) kg m ⁻³	0.56	0.66	0.59	0.57	0.59
8.	Yield, t ha ⁻¹	4.280	5.085	4.565	4.400	4.525
2008-2009						
1.	Net profit, \$	132.9	97.9	220.9	315.1	189.9
2.	Total variable costs, \$	549	556	482	468	468
3.	Gross productivity, kg m ⁻³	0.32	0.38	0.41	0.48	0.52
4.	Gross productivity, UZS/1000m ³	18786	16815	38384	61594	37130
5.	Gross productivity, \$/1000 m ³	12.6	11.3	25.8	41.4	24.98
6.	Gross productivity WP, kg m ⁻³	0.32	0.38	0.41	0.48	0.52
7.	Water productivity, (yield/ET total) kg m ⁻³	0.47	0.45	0.49	0.51	0.54
8.	Yield, t ha ⁻¹	33.8	32.8	35.45	36.9	39.5

6.3.5 Discussion

921. Experiments were successful as experiment trails with different leaching practices applied for winter wheat under groundwater level maintained at 1.0 m depth (shallow drainage) in lysimeters and field trials helped to identify technologies that greatly reduce water requirements without any yield losses in good drainage conditions.

922. The winter wheat is rather new crop for Uzbekistan and such kind of research activities were conducted for the first time. Leaching requirements for pre-sowing soil leaching for winter wheat crop on the saline soils can be much easier in comparison with traditional crop - cotton. There are possibilities to reduce leaching rate by 1500 m³ ha⁻¹ or preliminary to sow winter wheat with immediate application of 50 % of Nitrogen fertilizers with later combining of soil leaching with pre-sowing irrigation at the rate of 1500 m³ ha⁻¹. Good results were obtained in the treatments under zero-tillage and with plant residues. Using for first portion of irrigation of saline drainage water with EC of 5-7 mS cm⁻¹ allowed saving water resources and improving ecological conditions. Total, water and labor costs will be saved without reduction in water and

land productivity. Under testing of different soil leaching pre-sowing treatments for cotton production in 2009, the most effective was conducting of preliminary soil leaching with laser system, and postponing of leaching schedule from mid-winter time to the last days of February and early March. Good growth and development of cotton was achieved under soil leaching rate of $1500 \text{ m}^3 \text{ ha}^{-1}$.

923. It is necessary to organize efficient on-timely soil preparation activities, crop sowing and irrigation. For this it is required to maintain high technical level of tractors of farmers, petrol and available water resources. Studies on reducing water application for saline soil leaching in integration with mid-season irrigations, farming practices, drainage issues were not completely studied and require further investigations. There is need to continue the study on integration of the soil leaching with irrigation on lysimeters and to establish the experimental plot.

924. From the investigated technologies, for further dissemination it is possible to recommend treatments "b", "c", "d" which allowed reducing the water use by $1500 \text{ m}^3 \text{ ha}^{-1}$, to use saline collector-drainage waters for leaching under cultivation of winter wheat. Under conducting of soil leaching before cotton planting, it is recommended to postpone the soil leaching event to the end of winter and on the beginning of spring. In all cases efficiency of soil leaching and water use improves after land leveling with use of the laser system. At decrease in expenses of water resources on the salted soils it is necessary to conduct the operative control over salinity and soil moisture content by the express methods (Electroconductometer, EM-38, soil moisture meter "Diviner – 2000", tenziometers) and drainage performance. It is necessary to organize carefully the farming practices under appropriate technical conditions of the technical means.

6.3.6 Conclusions

925. Lysimeter research of various technologies of soil leaching by modeling of shallow groundwater level (shallow drainage) has allowed identifying the appropriate water saving technologies without reduction in crop productivity. Such positive result was achieved by creation in lysimeter necessary drainability by pumping of water in demanded volumes during soil infiltration. In the future, it is necessary to continue this research and also to establish experimental site.

926. At cultivation of winter wheat on the salted soils it is possible to simplify the problem of soil leaching. In conditions of the Hungry steppe, in order to save water the first portions of leaching water up to $700 \text{ m}^3 \text{ ha}^{-1}$ could be pumped from drainage channel, and the subsequent $1000 - 1500 \text{ m}^3 \text{ ha}^{-1}$ from irrigation channels. The water and land productivity did not decrease under winter wheat sown after tillage and direct sowing with zero-tillage.

927. Soil leaching schedule postponed from traditional applied period - January and early February to the beginning of early spring season will allow saving of water resources through combining the soil leaching and pre-sowing irrigation. In all cases efficiency of leaching will

enhance under implementing precisely land leveling with laser equipment. Under introduction of the water-saving technologies there is need to use the express methods (EC meter, EM-38, soil moisture meter “Diviner-2000”, tenziometers), and to guarantee the appropriate operation of drainage system, agricultural machinery under implementing the farming practices.

6.3.7 Necessary Research for carrying out in the future

928. It is necessary to continue Research on lysimeters under introducing of crop rotation, involving main (wheat, cotton) crops, double and intermediate crops for the further fine-tuning water saving technologies towards integrating the soil leaching with pre-sowing irrigations. It is necessary to establish experimental site with depth of drainage about 1.5 m (as it plasticized in many countries of the world) to study its efficiency in Uzbekistan conditions.

929. Field experiments should be continued with main and double crop rotation to study water saving due to management of ground/drainage water, and agrotechnical (farming) practices.

930. Proposed research on lysimeters to study evaporation from groundwater, total crop evapotranspiration, to assess the optimal dates and soil leaching rates under focus of integrating of the soil leaching with mid-season irrigation, monitoring soil, groundwater salinity and soil moisture using express methods and meteorological information for irrigation schedule correction will serve as a strategy for adaptation to the climate change.

6.4 Uzbekistan: Activity 2a. Maintaining of favorable soil salinity balance in permanent raised-bed planted cotton-wheat irrigated systems

6.4.1 Materials and Methods

931. Experiments have been laid out on the farmer holding Esanbay Ota of Pakhtakor district in the Jizzakh region of Uzbekistan in order to assess soil leaching and water saving (By Dr. Ikramov) effect of different tillage technologies and cintercroipoing of technical and legume crops on crop yields. In this experiments plants residues were used in all plots except of those under farmer practices. The main task of the experiment was development of permanent raised-bed planted crop system.

6.4.1.1 Jizzakh experimental site

932. Experiments have been laid out on the farmer holding of Esanboy ota of Pakhtakor district in the Jizzakh region of Uzbekistan (Figure 117). According to the classification system of the Kachinskyi for particle-size distribution, the soil is light loam in texture. The soils are low saline and groundwater level ranged from 2.5 to 3.0 m. According to the soil humus, phosphorous and potassium content, the soil could be classified as poor, moderate and rich. Meteorological data is presented in Table 155.

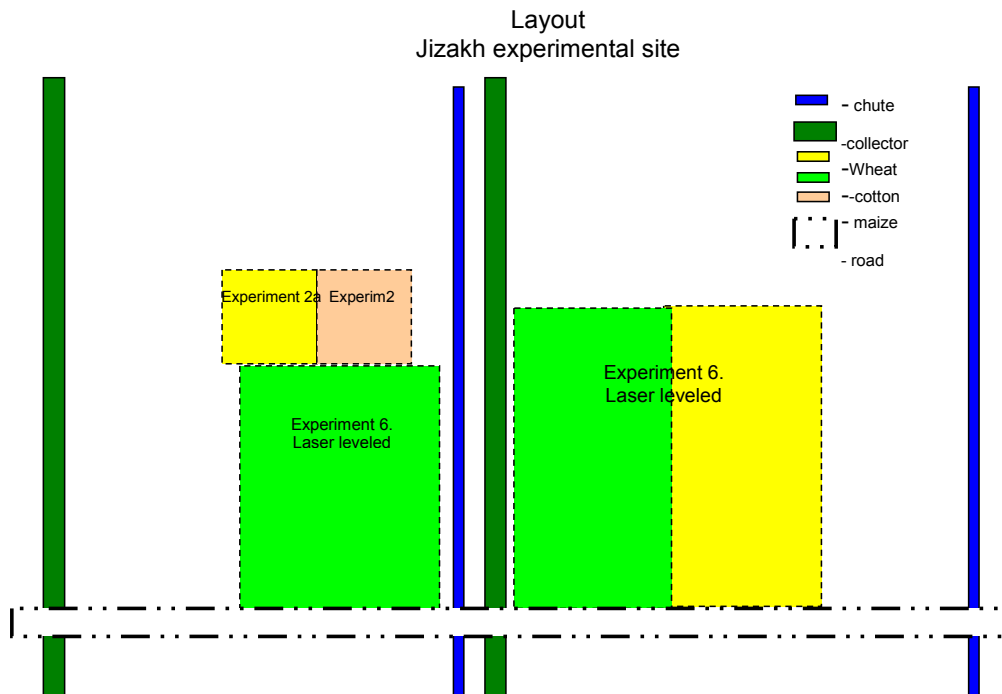


Figure 117. Schematic plan of the Jizakh site

Table 155. Meteorological data on Akaltyn station, which is representative for SLMR experimental sites located in the Jizzakh and Syrdarya provinces of Uzbekistan

Decades, monthly average, long-term average	Months, 2007											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Air temperature, °C											
1	-4.4	8.7	5.8	15.5	21	26.7	28.2	26.5	24.1	12.4	9.6	4.8
2	2.4	5.7	10.6	21.3	20.3	26.4	28.5	23.4	21.4	14.1	8.5	3.2
3	6.8	3.5	12.2	20.6	24.6	28.7	27.7	25.3	14.8	9.8	7.1	-2.5
average	1.9	6.1	9.6	19.1	22.1	27.3	28.1	25.1	20.1	12	8.4	1.8
long-term	1.2	0.7	8.3	15.7	21	25	26.7	24.3	18.5	12.8		
	Precipitation, mm											
1	4.9	11.3	29	3.9	5.5	0.4	0	0	0	0		30.4
2	13.2	3.4	5.9	23.9	22.6	0	0	0	0	0		23.3
3	0	28.5	54	4.7	0	0	0	0	0	0		18.7
average	18.1	43.2	88.9	32.5	28.1	0.4	0	0	0	0	13.4	72.4
long-term	39	39	55	55	26	6	2	1	0.4	25		
	Months, 2008											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Air temperature, °C											
1	-5.9	-7.4	10.7	15.9	21.1	27.9	28.3	28.2	21.8	18.5	9.4	5.05
2	-11.7	-2.8	15	15.5	24.2	28.7	29.5	25.8	21.0	15.4	4.9	3.5
3	-12.7	4.4	17.3	20.6	25.8	28.0	28.9	26.9	16.3	11.1	11.1	2.65
average	-10.1	-1.3	14.3	17.3	23.7	28.2	28.9	27.0	19.7	15.0	8.4	3.73
long-term	1.2	0.7	8.3	15.7	21	25	26.7	24.3	18.5	12.8		
	Precipitation, mm											
1	21.6	4.3	16.9	4.6	1.4					0	39.1	0
2	10.5	25.6	0	18.2	1.4					10.3	1.2	25.5
3		18.8	0	7.7	30.6		2.7			19.9		11.7
average		48.7	16.9	30.5	33.4		2.7			30.2	40.3	37.2
long-term	39	39	55	55	26	6	2	1	0.4	25		
	Months, 2009											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Air temperature, °C											
1	3.9	6.4	9.15	13.6								
2	2.7	7.95	13.1	13.7								
3	4.2 5	7.3	13.7	15.0								

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average	3.6 1	7.22	11.9	14.1								
long-term	1.2	0.7	8.3	15.7	21	25	26.7	24.3	18.5	12.8		
	Precipitation, mm											
1	22. 7	23.4	17.1	23.7	2.0							
2	0.3	15.6	27.2	26.5	10.5							
3	6.1	1.9	9.8	48.9	25.9							
average	29. 1	40.9	54.1	99.1	38.4							
long-term	39	39	55	55	26	6	2	1	0.4	25		

6.4.1.2 Experimental set-up

933. The experimental layout of different raised bed planted winter wheat (Yuj-12 variety) treatments is presented in Table 156.. The area of each treatment was kept at 0.14 ha (14.4×100m). Total area is 0.43 ha.

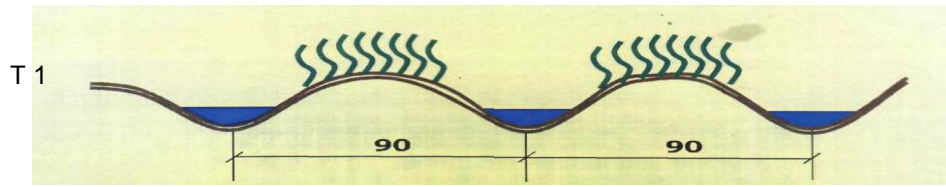
Table 156. Experimental layout of raised bed planted winter wheat treatments.

№ treatments	Scheme of experiment	Sowing method
1	A	Traditional sowing by broadcasting
2	B	Sowing on raised beds with Indian planter without plant residues. Raised beds/furrows (depth of 15 cm). Sowing in 90 cm raised beds in 4 rows with interrow space of 15 cm
3	C	Sowing on raised beds with plant residues

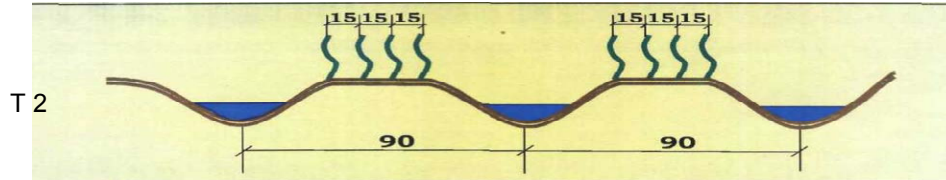
934. Experiment was established in one replication. Each subplot has 16 rows, size of 14.4×100 m, area of 0.14 ha. Double crops (maize and mung bean) were planted after winter wheat harvesting using Indian raised bed planter (Figure 120, Figure 118, and Figure 119). The following treatments were established: (1) Maize planted in middle of raised bed, control, 90 cm, (2) Zero till planted maize in two rows on 90 cm raised beds, (3) Zero till planted maize+mung bean in two rows on 90 cm raised beds. Intermediate crop (barley) was planted with Indian raised bed planter using zero till technology after harvesting of the double crops (Figure 121).

935. In 2009, double crops were planted according to treatments again on the same plots using zero-till technology (Figure 122)

Traditional sowing



Raised bed planting



Raised bed planting with plant residues

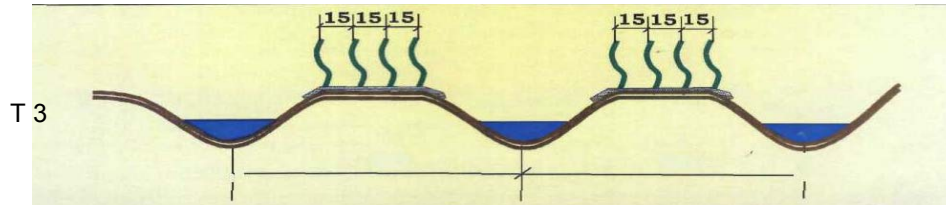


Figure 118. General scheme of winter wheat sowing in raised bed planting system

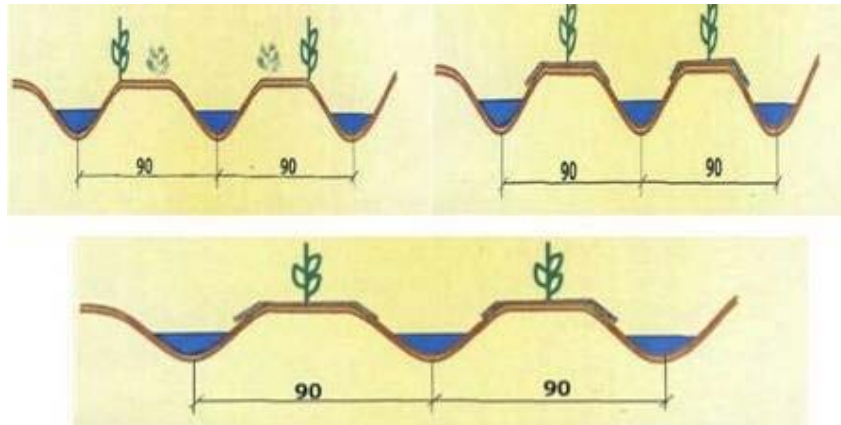


Figure 119. General scheme of intercropped sowing of maize and mung bean in raised bed planting system

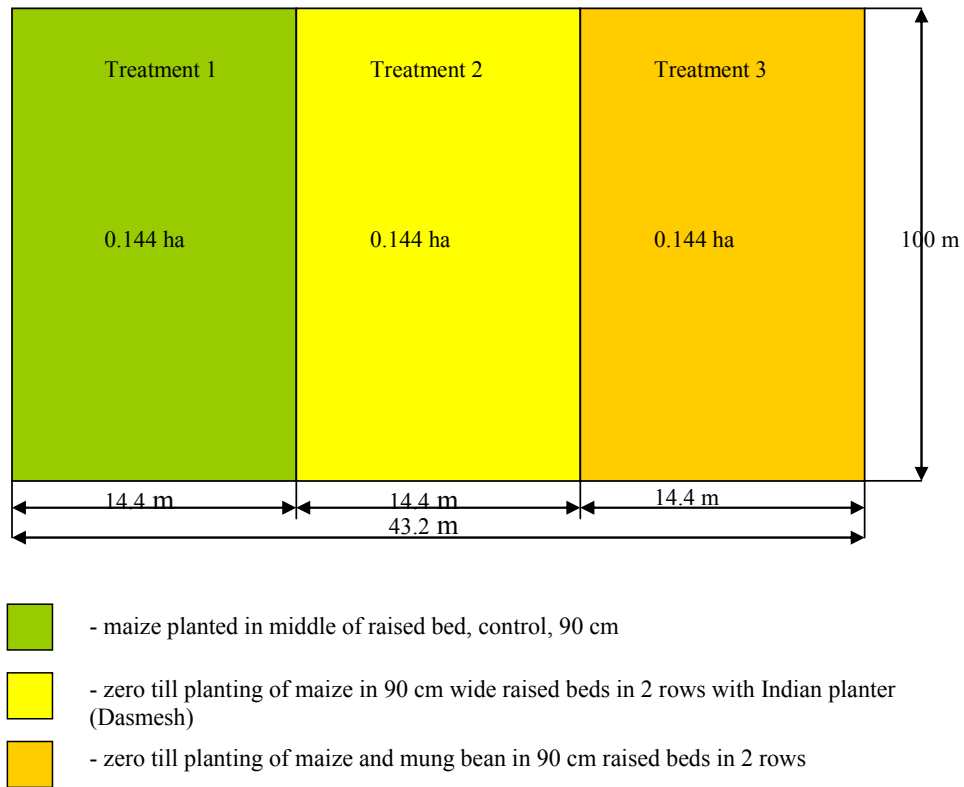


Figure 120. Experimental layout of double crops (maize and mungbean) planted in raised beds

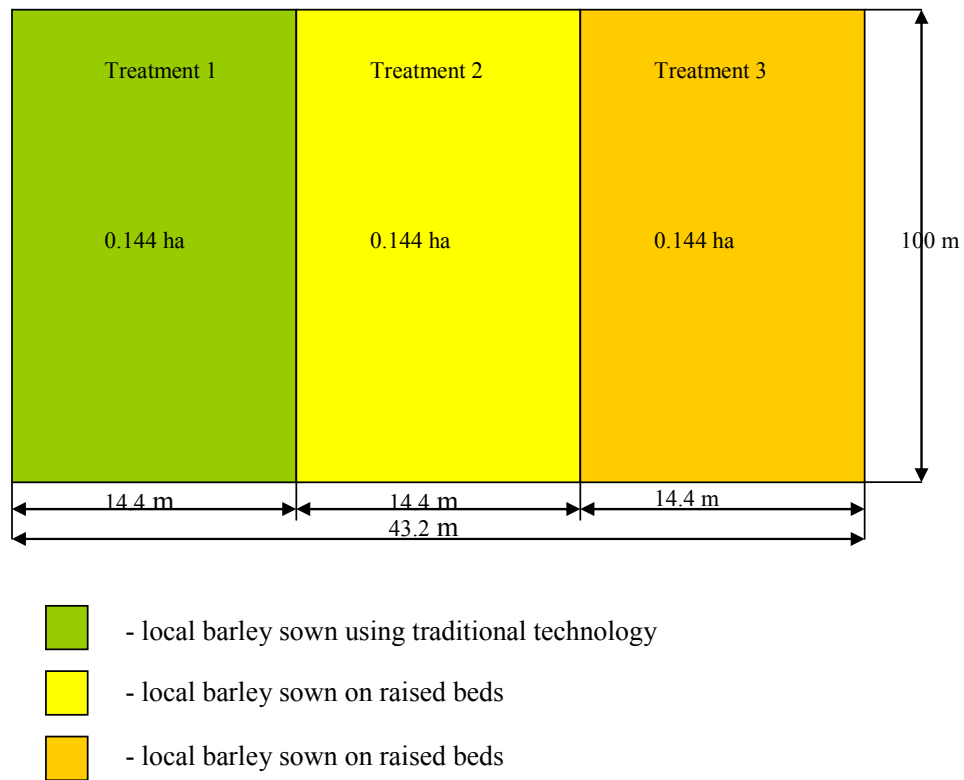


Figure 121. Experimental layout of double crops (maize and mungbean) planted in raised beds

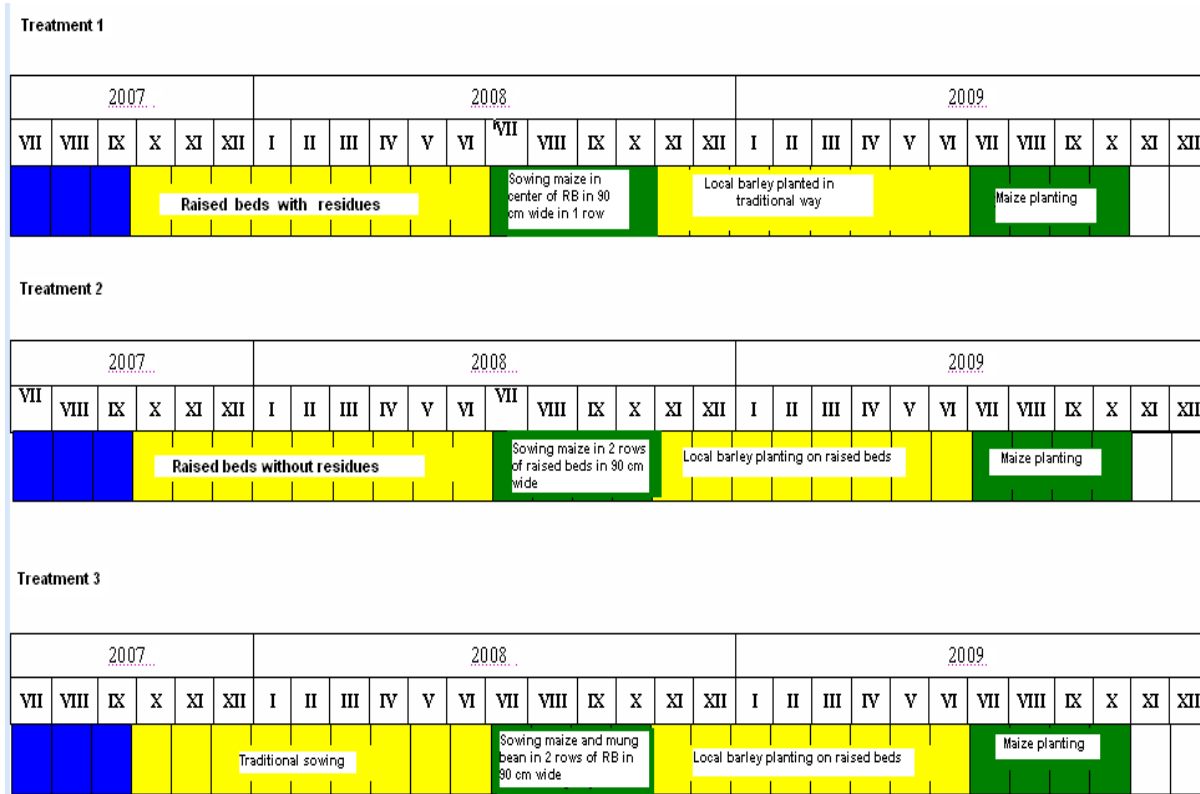


Figure 122. Scheme of grain and legumes crops rotation over different sowing options under permanent raised bed system.

6.4.2 Results

936. The soil leaching was applied at the rate of 2000 m³ ha⁻¹ in experimental site on 8.09.2007. On 26.09.09 field trials were launched with winter wheat “Yuj-112” variety, comprising of 3 treatments. Farming practices applied for cultivation of winter wheat “Yuj-112” variety are presented in Table 157.

937. Salinity determinations made on soil samples collected after harvest of winter wheat under no-mulch treatments 1 and 2 (10.06.2008) reveal the 58.2-73.0 % and 73.0-95.0% increases in TDS at the soil depths of 0-30 cm and 30-50 cm with respective to the pre-experiment levels (10-12.10.2007) (Table 158 and Table 159). There were no significant changes in salinity level of toxic salts after winter wheat harvest under soil mulching treatment (treatment 3) at the soil depth of 0-30 cm, while the salinity level was reduced by 35.3% under at the soil depth of 30-50 cm over the respective initial levels (10-12.10.2007).

938. Thus, soil mulching, through reduction of physical evaporation from the bare soil surface, assists to reduce the upward movement of salts from shallow saline groundwater to crop root zone through capillary rise. This ameliorative effect of mulch, however, requires

detailed check within several years. Winter wheat phonological observation and grain yield data are presented in Table 160.

Table 157. Farming practices applied for growing of winter wheat Yuj-12 variety

№№	Farming practices	Dates of implementation
1	Soil tillage	20.08.07
2	Soil leaching	8.09.07 (2000 m ³ ha-1)
3	Harrowing	16-24.09.07
4	Land leveling	20.09.07
5	Winter wheat sowing	26.09.07
6	Irrigations	27.09.07 (700 m ³ ha-1); 12.11.07(800 m ³ ha-1); 20.03.08 (800 m ³ ha-1); 7.04.08 (700 m ³ ha-1). Irrigation rate = 4000 m ³ ha-1
7	Mineral fertilizers applications	11.11.07;7.03.08; 7.04.08
8.	Herbicides applications	2.04.08
9	Manual weeding	12.05.08
10	Winter wheat harvesting	30.06.08

8.	Herbicides application	2.04.08
9	Manual weeding	12.05.08
10	Winter wheat harvesting	30.06.08

Table 158. Chemical properties of the field site before start of the experiment (10-12.10.07)

№	№ treatment	Soil depth, cm	TDS, %	HCO ₃ ²⁻ , %	Cl ⁻	SO ₄ ²⁻	Salinity degree
1	Control	0-30	0.335	0.040	0.024	0.142	Slight
2		30-50	0.315	0.027	0.028	0.125	Slight
3		50-80	0.430	0.037	0.024	0.197	Slight
4		80-100	0.645	0.030	0.021	0.356	Slight
5	2 nd treatment	0-30	0.365	0.040	0.024	0.154	Slight
6		30-50	0.370	0.027	0.021	0.169	Slight
7		50-80	0.260	0.033	0.014	0.121	Slight
8		80-100	0.445	0.033	0.010	0.234	Non saline
9	3 rd treatment	0-30	0.590	0.046	0.017	0.321	Slight
10		30-50	0.920	0.027	0.014	0.535	Slight
11		50-80	0.955	0.027	0.035	0.514	Moderate
12		80-100	1.195	0.024	0.045	0.658	Moderate

Table 159. Chemical properties of the field site at the end of the winter wheat experiment (10.06.08)

Treatments	Soil depth, cm.	TDS, %	HCO ₃ , %	Cl, %	SO ₄ , %
T-1 Control, traditional method of sowing	0.30	0.530	0.043	0.021	0.290
	30-50	0.545	0.037	0.037	0.265
T-2 Raised bed sowing with Indian seeder	0.30	0.615	0.024	0.038	0.313
	30-50	0.725	0.024	0.042	0.380
T-3 Raised bed sowing with Indian seeder +mulch	0.30	0.590	0.020	0.24	0.312
	30-50	0.680	0.021	0.028	0.368

Table 160. Plant height, plant density, grain yield as affected by different sowing method

Treatments	Plant height, cm			Plant density, No of plants/m ²	Number of ears, pieces/spike	Weight of grains per 1 spike, gram	Grain yield, t ha ⁻¹
	1.04	1.05	1.06				
1	63.7	88.4	115	482	28.7	1.25	6.00
2	69.1	92.8	117	460	30.6	1.40	6.44
3	71.3	93.1	120	467	32.0	1.45	6.85

939. Apparently, the highest grain yield was received on treatment related to wheat sowing on raised beds with plant residues (Treatment 3) (Table 160). The increase in grain yield under Treatment 3 in comparison with control was 0.85 t ha⁻¹ (14.2 %). Thus, the best soil processing of furrow ridges, sowing of wheat in lines with the Indian planter “Dasmesh”, and soil mulching

on raised beds by plant residues (which in turn provides the best water, thermal and gas regimes) helped to get high grain yield of winter wheat.

940. In order to get higher seedling emergence of double crop, pre-sowing irrigation was applied in late June-early July. Its rate together with total rate of irrigation water applied during crop mid-season was equated with the soil leaching rate, which maintained the optimum soil salinity regime.

941. If water is not sufficient for cultivation of double crops, the soil should be leached via furrows at the dates and rates, prescribed by regional recommendations. At the experimental site with the raised beds constructed in 2007, after harvesting of winter wheat crop (13.07.08) new experiment was established for sowing of double crops.

942. Nutrients elements determinations (Table 161) made on soil samples collected at initial crop stages of maize and mung bean reveal that maximum humus content was observed under 1st treatment (control), maximum mobile Phosphorous content was under 2nd treatment and maximum mobile Potassium was under 3rd treatment. According to the mobile Phosphorous content at the plowed depth (0-30 cm), the soil could be classified as “very poor” in 1st treatment and “poor” in 2nd and 3rd treatments. According to the mobile Potassium content at the plowed depth (0-30 cm), the soil could be classified as “very poor” in all treatments. Hence, the soils are needed to supply with all nutrient elements. Results of soil chemical analyses at harvesting stage are presented in Table 162.

Table 161. Agrochemical characteristics of the soils at experimental site

Treatment	Soil depth, cm	Humus content, %	Concentration of nutrient forms, %			Concentration of mobile forms ,mg kg-1	
			Nitrogen	Phosphorous	Potassium	Phosphorous	Potassium
1	0-30	1.1424	0.094	0.140	0.94	5.2	131
	30-50	1.2512	0.070	0.142	1.02	5.0	142
	0-50	1.196	0.082	0.141	0.98	5.1	136
2	0-30	0.6200	0.066	0.122	1.12	26.0	131
	30-50	0.7616	0.072	0.150	1.41	5.8	131
	0-50	0.6908	0.069	0.136	1.26	15.9	131
3	0-30	0.5712	0.046	0.140	1.19	15.0	153
	30-50	0.5440	0.070	0.164	1.63	5.2	164
	0-50	0.5576	0.058	0.152	1.41	10.1	158

Table 162. Soil chemical properties of different treatments

Treatments	Soil depth, cm	TDS, %	HCO ₃ , %	Cl, %	SO ₄ , %
T-1	0-30	1.060	0.021	0.035	0.566
	30-50	0.835	0.021	0.024	0.327
	50-70	0.835	0.018	0.045	0.438
	70-100	0.860	0.021	0.024	0.471
	0-100	0.847	0.020	0.032	0.459
T-2	0-30	1.110	0.027	0.021	0.610
	30-50	0.795	0.021	0.017	0.445
	50-70	0.560	0.018	0.014	0.304
	70-100	0.860	0.021	0.031	0.492
	0-100	0.831	0.021	0.020	0.465
T-3	0-30	0.880	0.027	0.021	0.376
	30-50	0.575	0.033	0.014	0.319
	50-70	0.925	0.030	0.014	0.512
	70-100	0.775	0.024	0.021	0.434
	0-100	0.738	0.028	0.017	0.410

943. Apparently, there was an accumulation of toxic salts in an arable soil depth of the first and second treatments by the end of crop season therefore soils of the site have transformed to the category of “moderate saline” soils. At the same time, according to the salts content in 1 m soil profile, the soils could be classified as “slightly saline”. Thus, there is the positive effect of the soil mulching with plant residues on the soil salinity, i.e. soils are less accumulated in the root-zone.

944. Soil salinity level at the soil profile had an increasing trend from bottom of furrow to the crest of the raised-beds under raised bed system (Figure 123). However, there was no effect of soil salinity on grain crop yields in Syrdarya and Jizzakh provinces for the last two years.

945. However, there is need in additional (long-term) studies in order to validate this fact. List of the farming practices conducted under cultivation of maize and mung bean crops is presented in the Table 163.

946. Maize and mung bean crop attributes are presented in Table 164. Results of phenological supervision over growth and development of maize and mung bean are presented in Table 164.

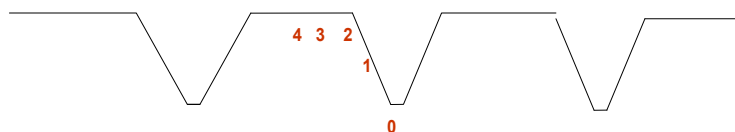


Figure 123. Soil salinity profile characteristics under raised bed system measured by EC meter “Progress 1T” (mS cm⁻¹)

Table 163. Farming practices applied for planting of maize crop

№	Farming practices	Dates implementation of treatments 2, 3	Dates of implementation at treatment1
1	Chiseling and harrowing		13.07
2	Sowing	13.07	13.07
3	Weeding	26.07; 06.08	26.07; 06.08
4	Fertilization, 400 kg NH ₄ NO ₃	2/08	2/08
5	Irrigation	14/07 (500 m ³ ha-1), 03(700 m ³ ha-1),08 21.08(700 m ³ ha-1), Irrigation rate of 1900 m ³ ha-1	14/07 (500 m ³ ha-1), 03(700 m ³ ha-1),08 21.08(700 m ³ ha-1), Irrigation rate of 1900 m ³ ha-1

Table 164. Biometric parameters of maize and mung bean

Treatments	Maize plant density thousands ha ⁻¹	Number of maize ears, thousands. ha ⁻¹	Weight of 1 ear, g	Weight of 1000 grains, g	Yield of maize grains, t ha ⁻¹	Grain yield of mung bean, t ha ⁻¹	Total grain yield, t ha ⁻¹
1	42.5	43.7	87.6	251.2	3.45		34.5
2	52.6	56.1	90.1	256.7	4.63		46.3
3	46.2	48.2	89.7	258.7	3.86	1.32	51.8

947. As it is seen from the Table 164, maize yields in experimental trials were significantly higher than that in control. Although maize yields in third treatment were lower than that in the second treatment, however the total grain yield of maize and mung bean in third treatment was higher than that in the second treatment.

948. At the same time it is necessary to note, that in the given experiment the silage weight of both cultures was not considered. Their silage weight is valuable forage for the large horned livestock which is available in each farmer holdings.

949. After harvesting of double crops (corn and mung bean), winter barley was sowed on October 28th, 2008. In this experiment three treatments were established:

1. Sowing on the plowed field;
2. Sowing without ploughing by the Indian seeder on the field previously sown by maize;
3. Sowing without ploughing by the Indian seeder on the field previously sown by maize and mung bean (Figure 124).

950. Results of phenological supervision over growth and development of barley and grain yields of barley by experimental treatments are presented in Table 165.

951. Data cited in Table 165 indicate that all crop attributes and yields are higher in treatments where barley planted in raised beds in comparison with traditional planting (control). Increase in crop yield from treatments 2 and 3 were in the order: 0.45 t ha⁻¹ or 13% (treatment 3) and 0.20-0.24 t ha⁻¹ (treatment 2) over control.

952. Thus, it was possible to get high crop yields, especially under intercropped sowing of maize with legume crops without soil tillage within two years on low-saline, light loam soils in conditions of Hungry steppe.

Table 165. Barley crop growth and development attributes and its grain yields

Treatments	Plant height, cm.			Number of stems per 1 m ² , pieces	Number of spikes per 1 m ² , pieces	Weight of 1 spike, g	Grain yield, t ha ⁻¹
	1.04	1.05	1.06				
1	51.6	78.6	103.2	260	39.2	1.33	3.45
2	53.3	79.4	106.1	268	40.3	1.36	3.69
3	54.2	81.1	106.9	256	42.2	1.49	3.80



Figure 124. Sowing of intermediate crop –barley in permanent raised bed system after harvesting of maize and mung bean

6.4.3 Discussion

953. Sowing of different crops on raised beds on light loamy soil during two years, without traditional for the region annual soil tillage, has demonstrated its positive effect on the water-physical, agrochemical and chemical properties of the soils and crop yields.

954. Two row Indian planter (model: Dasmesh) is less efficient but 4 row new multi crop planter was too heavy in order to couple up with wheel tractors such as MTZ-80 and TTZ-100. There is need to reduce the weight of the 4 row seeder.

955. Method of sowing winter wheat on raised beds with mulching by plant residues is a new and a perspective technology that allows getting higher grain yields under substantially seed savings for Uzbekistan farmers

956. Another perspective technology is intercropping of 2 crops – maize and mung bean on raised beds. This method allows both getting higher grain yields and enhancing the soil fertility due to cultivation of lentil crop and plough of above ground biomass of lentil crops containing great amount of biological Nitrogen. This study was implemented for the first time.

957. Two technologies tested under SLMR project are to be recommended for introducing and up scaling namely, planting of winter wheat on raised beds with mulching by plant residues, intercropping planting of 2 crops – maize and mung bean on permanent raised beds.

958. Sowing of maize in intercropping with mungbean Zilola and Marjon varieties revealed that these new mung bean varieties are high yielding and suitable for planting with maize. It is planned to study the possibilities to get 2 mung bean yields in 1 year. Moreover, winter wheat Yj-12 (Yujniy Kazakhstanskyi) variety over-yielded the local winter wheat cultivars and this variety should be disseminated in larger scale.

6.4.4 Conclusions

959. Method of sowing winter wheat on raised beds with mulching by plant residues is a new and a perspective technology that allows getting higher grain yields under substantially seed savings for Uzbekistan farmers.

960. Intercropping of 2 crops – maize and mung bean on raised beds is a perspective method. This method allows both getting higher grain yields and enhancing the soil fertility due to cultivation of lentil crop and plough of above ground biomass of lentil crops containing great amount of biological Nitrogen. This study was implemented for the first time.

6.4.5 Necessary Research for carrying out in the future

- Two row Indian planter (model: Dasmesh) is less efficient but 4 row new multi crop planter was too heavy in order to couple up with wheel tractors such as MTZ-80 and TTZ-100. There is need to reduce the weight of the 4 row seeder.
- There is need to conduct the study on the possibilities to get 2 harvest yields of 2 mung bean (Zilola and Marjon) varieties under crop intercropping in one year.
- It is highly advisable to study dynamics of legume and nitrogen-fixing bacteria in the undisturbed soils during several years.

- The multi-crop seeder “Dasmesh” has to be modified in order to get opportunities to sow seeds of cotton, winter wheat, mung bean and maize on the selected depth with optimum seedling rate.

6.5 Uzbekistan: Activity 2b. Indicators of growing cotton with mung bean using raised bed planter

6.5.1 Methodology

961. In another field trial at the Pakhtakor research station, cotton was sown on 90 cm and 60 cm wide raised beds with intercropping of mung bean- a legume crop. The following treatments were established in Esanboy ota farm:

- Treatment 1. Raised-bed cotton-mung bean planting with the 90 cm width between rows.
- Treatment 2. Raised-bed cotton planting with the 90 cm width between rows (control).
- Treatment 3. Raised-bed cotton-mung bean planting with the 60 cm width between rows.
- Treatment 4. Raised-bed cotton planting with the 60 cm width between rows

962. The experimental layout is depicted in Figure 125 and Figure 126.

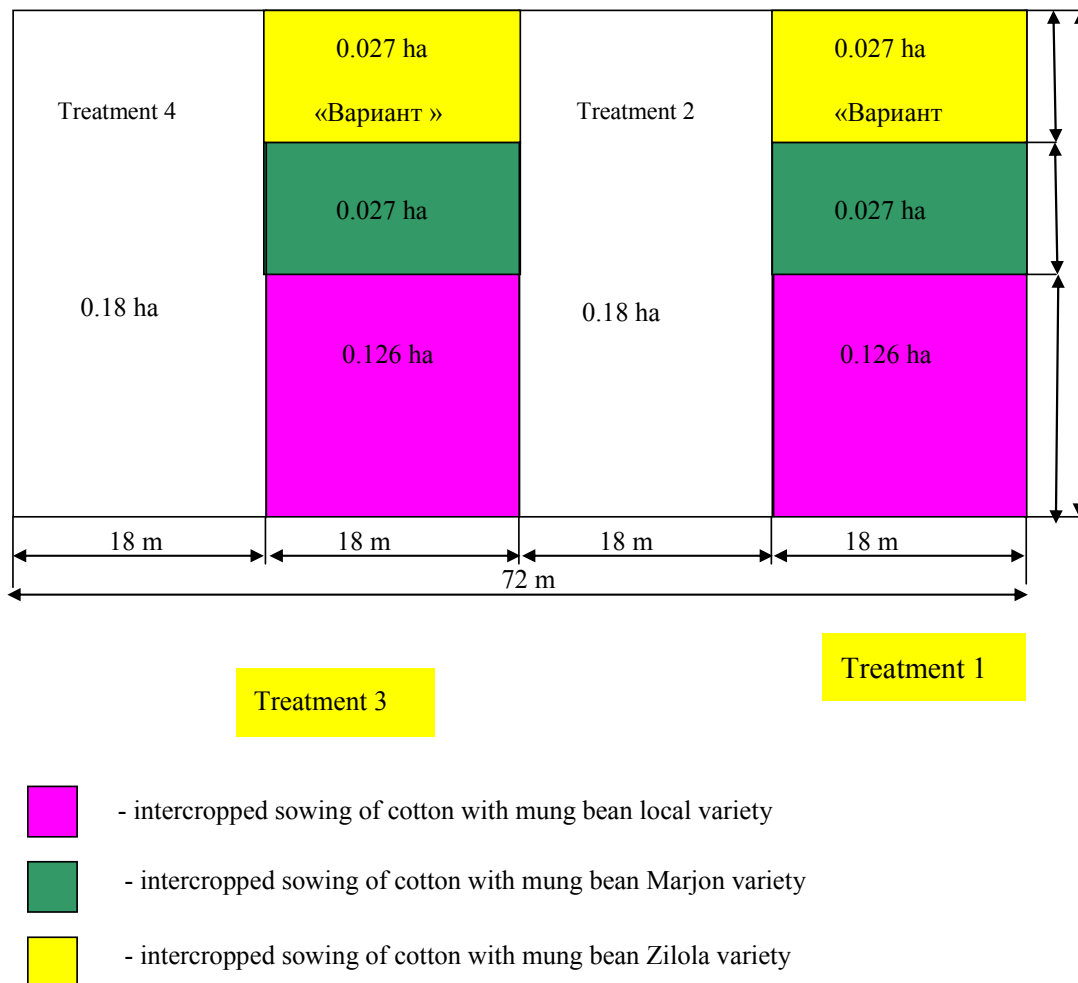
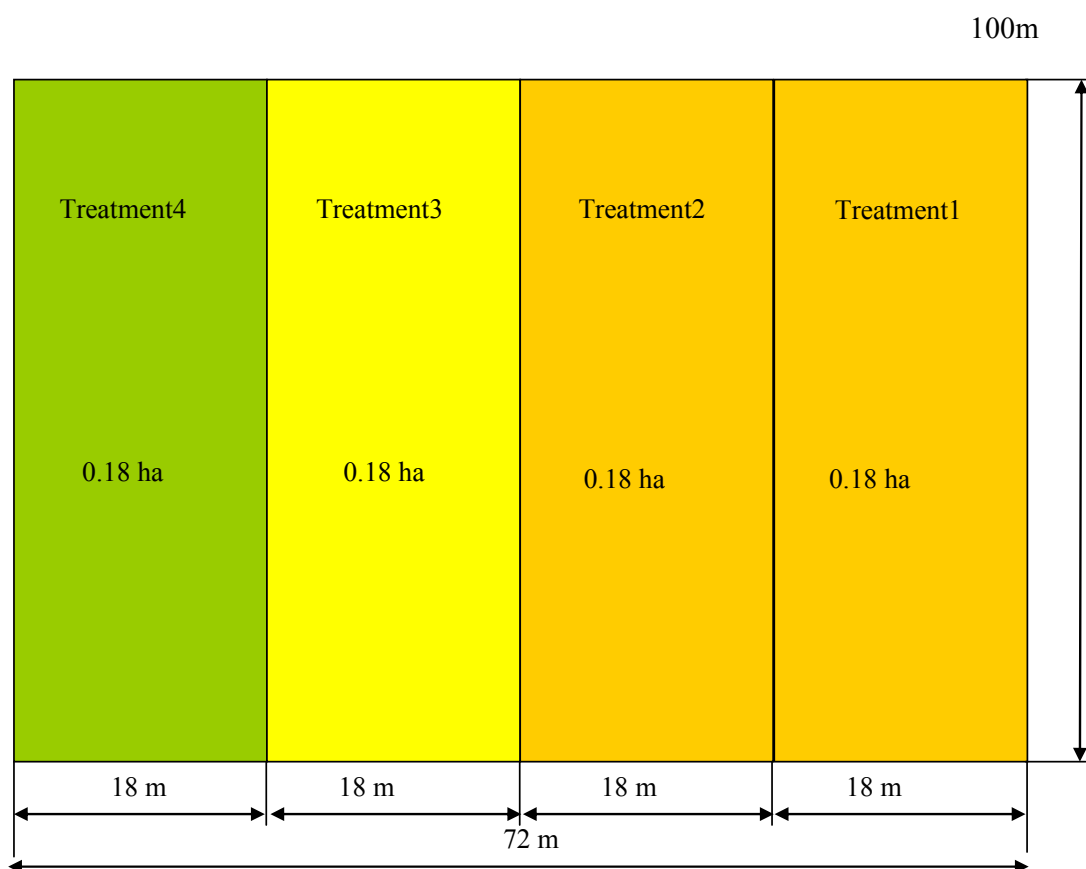


Figure 125. Experimental layout of intercropped sowing of cotton “Buhara-102” variety with legume crops and alone planted under 90 and 60 cm raised-beds on experimental site (0.72 ha)



Treatment 1 – study of mung bean effect (a = 90 cm)

Treatment 2– control (a = 90cm)

Treatment 3 – study of mung bean effect (a = 60 cm)

Treatment 4 –control (a = 60 cm)

Figure 126. Layout of arrangements of different sowing treatments of winter wheat “Zamin” variety under 90 cm and 60 cm raised beds in Esanboy ota farm in Pakhtakor district

963. In the spring (10.04.08) field experiment on studying efficiency of new technology of cultivation of cotton in intercropped sowing with mung bean has been established in permanent raised bed system (Figure 128, Figure 127).



Figure 127. Sowing of cotton and mung bean using Indian planter “Dasmesh”

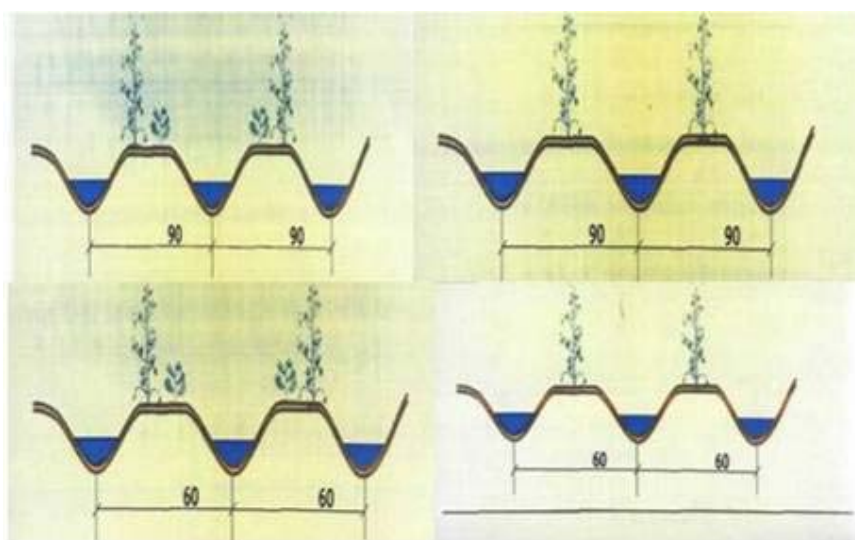


Figure 128. Intercropped sowing of cotton and mung bean in raised bed systems

6.5.2 Results

964. At planning of the experiment it was supposed, that soil processing in variants 2-4 will be carried out by different mechanisms. However, due to shortage of agricultural machinery in the farm (as well as in the prevailing majority of farms), the perforated film was placed in the irrigated furrows in order to eliminate necessity of carrying out of inter-row soil processing operations.

965. Experimental trials were implemented in one replication. Each plot had length of 100 m, with its area of 0.25 hectares. Nutrients and salinity determinations made on soil samples collected after harvest of winter wheat are presented in Table 167 and Table 166. Phenological observation data over cotton growth and development are presented in Table 169 and Table 170. Farming practices applied for cotton and mung bean crops are presented in Table 168.

Table 166. Total dissolved solids and concentration of soluble ions in the soil, %

Treatment	Soil depth, cm	NDS, %	HCO ₃ , %	Cl, %	SO ₄ , %
T-1	0-30	0.895	0.037	0.024	0.467
	30-50	1.045	0.030	0.017	0.553
	50-70	0.740	0.030	0.014	0.720
	70-100	0.670	0.027	0.014	0.354
	0-100	0.837	0.031	0.017	0.448
T-2	0-30	0.580	0.030	0.014	0.311
	30-50	0.475	0.024	0.014	0.245
	50-70	0.525	0.018	0.014	0.286
	70-100	0.490	0.021	0.010	0.261
	0-100	0.517	0.023	0.013	0.275
T-3	0-30	0.705	0.024	0.042	0.360
	30-50	0.785	0.018	0.042	0.424
	50-70	0.865	0.024	0.045	0.457
	70-100	0.650	0.021	0.035	0.339
	0-100	0.751	0.021	0.041	0.395
T-4	0-30	0.815	0.020	0.021	0.463
	30-50	0.720	0.027	0.021	0.395
	50-70	0.640	0.021	0.014	0.358
	70-100	0.600	0.027	0.021	0.317
	0-100	0.693	0.023	0.019	0.383

Table 167. Agrochemical characteristics of the soils of experimental site

Treatment	Soil depth,cm	Humus content, %	Content of gross forms of nutrients , %			Content of mobile forms of nutrients, mg kg-1	
			N	P	K	P	K
1	0-30	1.3058	0.074	0.094	0.87	10.0	265
	30-60	0.9248	0.086	0.106	0.74	5.9	208
	0-50	1.1153	0.080	0.101	0.80	7.9	236
2	0-30	1.4960	0.098	0.134	1.25	15.0	142
	30-60	0.6800	0.038	0.144	1.34	5.9	142
	0-50	1.0880	0.068	0.139	1.29	10.4	142
3	0-30	1.4460	0.062	0.142	1.05	10.0	142
	30-60	0.7344	0.040	0.136	1.37	5.1	164
	0-50	1.0902	0.051	0.139	1.21	7.5	153
4	0-30	0.9242	0.068	0.156	1.74	5.9	175
	30-60	0.5712	0.092	0.160	1.50	5.0	142
	0-50	0.7477	0.080	0.158	1.62	5.4	158

Table 168. Farming practices

№	Farming practices	Dates of implementation
1	Soil tillage	8.11.07
2	Soil leaching	12.11.07
3	Harrowing	10.03.,27.03., 8.04.08
4	Chiseling	27.03.
5	Planting of cotton and mung bean	10.04.08
6	Irrigation	15.04. (500 m ³ ha-1) 26.06 (750 m ³ ha-1) 18.07. (800 m ³ ha-1) 05.08. (600 m ³ ha-1)
7	Wedding	01.05., 20.06., 20.07.
8	Cultivation	05.05., 20.05.
9	Top removal of cotton	20.07.,27.07.
10	Defoliation	02.09.
11	Harvesting of raw cotton	02.10., 17.10.
12	Harvesting of mung bean	10.09.

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Table 169. Cotton growth and development parameters

Treatment	1.06.08.		1.07.08.						1.08.08.					1.09.08.	
	Plant height, cm	Number of true leaves	Plant height	Number of fruitful branches	Number of buds	Number of flowers	Number of ovaries	Number of bolls	Plant height	Number of fruitful branches	Number of ovaries	Number of bolls	Number of flowers	Number of bolls	Including opened
1	17.5	6.5	55.1	10.1	14.8	0.6	1.6	2.2	95.5	12.1	6.1	7.1	1.7	16.1	4.8
2	18.6	6.8	56.3	10.9	15.8	0.9	1.8	3.4	97.6	13.4	8.9	9.3	1.6	18.5	3.6
3	16.4	6.3	52.7	9.5	12.2	0.5	1.5	2.1	83.3	10.4	5.0	4.9	1.2	12.3	4.4
4	16.6	6.0	53.4	9.2	14.1	0.7	1.6	2.6	90.1	11.12	6.1	4.5	1.6	14.1	3.1

Table 170. Phenological parameters of mung bean local variety

Treatment	1.07.08.			1.08.08.			1.09.08.		
	Plant height, cm	Number of fruitful branches	Number of pods	Plant height, cm	Number of fruitful branches	Number of pods	Plant height, cm	Number of fruitful branches	Number of pods
1	28	4	11	47	5	14	68	6	18
3	24	4	10	42	4	12	62	5	16

966. Maximum cotton yield was obtained in Treatment 2 with inter-row space of 90 cm, under intercropped sowing with mung bean on raised beds – 5.41 t ha⁻¹ (Figure 129), while yield of mung bean of Marjon variety under intercropped sowing with mung bean on raised beds was maximum and equal to 1.88 t ha⁻¹ (Table 171).

Table 171. Raw cotton yields and mung bean grain yield

Treatment	Cotton yields, t ha-1			Mungbean grain yields, t ha-1		
	1 st pickup 2.10.08	2 nd pickup 17.10.08.	Total yield	Local variety	Zilola varietya	Marjon variety
1	3.60	1.22	4.82	1.44	1.57	1.88
2	3.20	2.21	5.41	-	-	-
3	2.40	1.44	3.84	1.32	1.48	1.69
4	2.80	1.66	4.46	-	-	-



Figure 129. Cultivation of cotton in intercropped sowing with mung bean and mulching on raised beds

967. Yields of cotton sown in the middle of raised beds (treatments 2 and 4) were higher than that sown in intercropping with mung bean with interrows 90 and 60 cm (treatments 1 and 3) by 0.59-0.62 t ha⁻¹ or 11-16.1%.

968. At the same time total yield of 2 crops (cotton + mung bean) is higher of the yield of cotton cotton sown in the middle of raised beds. In first treatment it was equal to 6.7 t ha⁻¹ and third treatment -5.53 t ha⁻¹.

969. Thereupon it is recommended to make economic assessment of the given technologies with taking into account that mung bean as a root nodule crop enhancing the soil fertility. In fall (10 October) winter wheat Polovchanka variety was sown in standing cotton (Figure 130). Farming practices are presented in Table 172.

Table 172. Farming practices and dates of implementation

No	Farming practices	Dates of implementation
1.	Soil loosening in inter-rows	20.10.2008
2.	Sowing of wheat in standing cotton	2.10.2008
3.	Fertilizers application	28.10.2008;10.03.2009;8.04.2009
4.	Irrigations	4.10.2008 (700 m ³ ha ⁻¹); 2.11.08 (800 m ³ ha ⁻¹); 8.04.09 (700 m ³ ha ⁻¹).
5.	Herbicide application	12.04.2009
6.	Manual weeding	10.05.2009
7.	Harvesting	15.07.2009

**Figure 130. Sowing of winter wheat in standing cotton**

6.5.3 Discussion

970. As a whole, experiment was successful. In scientific circles till now there is a dispute on optimum inter-row width to be applied for cotton. There are supporters of transition from wide rows to narrow-rows. Experimental trials have shown that wide-row planted crops gave higher cotton yield. Intercropping of cotton and mung bean has showed higher efficiency since there is a possibility to get yields of 2 crops, technical (cotton) and food crop (mung bean), the latter enriches soil with biological Nitrogen, maintain the soil fertility level and improve soil biological activity.

971. It is highly advisable to cultivate cotton together with mung bean of new early ripening varieties for Hungry steppe. Sowing of these two crops should be done under the original layout offered by ICARDA.

972. At planning of the experiment it was supposed, that soil processing will be carried out by different mechanisms, involved in different machines developed for 60 and 90 cm inter-rows while 90 cm wide sowing mechanisms are widely used in crop sowing in Hungry steppe. That is why it was designed to eliminate of interrow soil processing operations through soil mulching by perforated black polyethylene film. Perforated black polyethylene film has proved to be efficient in elimination of inter-row cultivation and getting highest yields of 2 cultivated crops – cotton and mung bean

973. Intercropping of cotton and mung bean was done first time. A slight change in the planting geometry of the cotton has opened a new window for introduction of the mung bean/legume crop. Successful cultivation of the crops was possible due to the Indian Multi-crop raised bed planter (model: “Dasmesh”) which allows to implement several operation (in a one pass operation), i.e. raised bed formation, cutting of furrows, seeding of seeds in loose soil and application of mineral fertilizers.

974. However it should be noted that there is need to upgrade the sowing machine in such way so it could be adjusted to sow the requisite number of seeds.

975. Earlier 3 year Research (early 80th of last century) were carried out in Pakhtaaral station of Uzbek Cotton research institute in Hungry steppe on studying efficiency of different cotton inter-rows of 60 and 90 cm under sprinkler irrigation and sowing of a cotton on smooth field has proved the 60 cm space as best option.

976. By results of experiment of cultivation of cotton in intercropping with mung bean it is possible to recommend the following technology: sowing of cotton and mung bean on raised beds, soil mulching by perforated polyethylene film, using of herbicides against weeds. Combining of raised bed sowing (ICARDA) with soil mulching (Uzbek Cotton RI) allowed to get a high crop yields of two crops, to save the petrol and irrigation water, to reduce the physical evaporation and to increase of fertilizers use efficiency.

977. Under cultivation of cotton with mung bean it would be highly advisable to determine content of free living and root nodule bacteria in the soil to find in what extend the soil enriched by biological Nitrogen. Another gap in research was related to the reason of getting of higher cotton row yields under 90 cm raised beds.

978. Sowing of winter wheat in standing cotton on wide rows (90 cm) provided the optimum conditions for growth, developments and accumulation of grain yield. As a result the grain yield appears higher than that in 60 cm beds, and, it is obvious, that it is desirable to plough the soil once in 2-3 years treatment related to sowing of cotton on the plowed field and leveled field.

6.5.4 Conclusions

979. Earlier intercropping of two crops (cotton and mung bean) was not practiced in Uzbekistan. Successful cultivation of the crops was possible due to the Indian Multi-crop raised

bed planter (model: “Dasmesh”) which allows to implement several operation (in a one pass operation), i.e. raised bed formation, cutting of furrows, seeding of seeds in loose soil and application of mineral fertilizers.

980. By results of experiment of cultivation of cotton in intercropping with mung bean it is possible to recommend the following technology: sowing of cotton and mung bean on raised beds, soil mulching by perforated polyethylene film, using of herbicides against weeds. Combining of raised bed sowing (ICARDA) with soil mulching (Uzbek Cotton RI) allowed to get a high crop yields of two crops, to save the petrol and irrigation water, to reduce the physical evaporation and to increase of fertilizers use efficiency.

6.6 Uzbekistan: Activity 3 and 4. Assessment of both native and non-native tree and grass species for their biomass productivity, salt tolerance and bio-drainage ability to rehabilitate the degraded rangelands in arid agro-ecologies; and Evaluation of diversified, salinity-resistant crops for enhancing biomass production for livestock in degraded rangelands

6.6.1 Introduction

981. Rangelands of the deserts and semi deserts of Uzbekistan, occupied more than 60% of the territory of the republic are the main source for fodders for desert livestock in particular for karakul breeding. These rangelands are suitable for using them almost for the whole year and give the cheapest fodders, however their productivity is very low (1-3 centner ha⁻¹) of air-dry weight. Together with this, yield of different rangelands can increase and reduce in 3-5 times with respect to an average yield year (Necheva N.T., Pelt N.N., 1969, Gaevskaya L.S., 1971; Burygin, Zakirov and others, 1956, Morozova, 1946; 1959; Morozov, 1969). Fodder reserves change not only with years but also with seasons and as a rule are reduced in winter in 2.5 times (Nechaeva, Pelt, 1963). Not only yield reduces but also the quality of fodder. According to the data of N.L. Morozov (1969) 100 kg of fodder in spring contain 81 fodder units, in summer – 49.5, in autumn – 54.0 and in winter – 18.3. In general rangelands fodder provides the animals needs in spring for 100%, in summer for 80-90%, in autumn for 60-70% and in winter for 30-50%. Thus, insurance fodder reserves should be created in order to provide nutrition security for animals, especially for additional feeding during autumn-winter period.

982. A number of technologies enabling to increase the productivity of desert rangelands were worked out for the purpose of strengthening the forage resources in Uzbekistan. (Shamsutdinov 1975; Shamsutdinov 1983, Ibragimov 1983; Makhmudov 1969; Ibragimov 1972).

983. Together with rangelands improvement by introduction to the culture of high productive forage plants a great importance has the creation of guaranteed forage reserves for the account of irrigation feed production. In desert conditions during winter period high level of feeding karakul sheep can be provided by correct combining of pasturing with additional feeding by rude and concentrated fodders. Development interests of karakul breeding in this district requires an improvement of forage resources, creation of guaranteed forage reserves for winter and spring period. A real chance for creating the forage resources with a help of irrigation in karakul production farms of Kyzylkum desert appeared after opening here artesian waters.

984. About half of existing Karakul sheep livestock of the Uzbek Republic belongs to the farms located in Kyzylkum desert. There is also great water shortage. According to the data of hydrogeologists explored reserves of groundwater in the desert constitute approximately 500

million m³. Operational and filling water reserves are equal to 250-300 million m³. With this water rate is possible to irrigate in the desert 25-30 thousand ha of lands, to cultivated forage and industrial crops.

985. According to our calculations annual demand of karakul sheep in the forage for extra nutrient is made 1.5 million centners of fodder units. In order to have such amount of forage from each irrigation hectare is necessary to get 12.0-15.0 t of hay, i.e. to carry out feed production on the basis of intensification.

986. A number of perspective fodder crops were determined during long-term Research of previous years. They are alfalfa, winter rye, Sudan grass, many times cut fodder sorghum, maize. A number of agro technical techniques were worked out for getting high yields from these perspective plants. On this basis were worked out the technologies of cultivating and using the perspective forage crops, which provide a big amount of forage units and protein from one hectare of irrigated arable land.

987. In the research of last 3 years we tried to select and test the most salt resistant, high productive non traditional forage crops. Subject of research were also high productive perspective types of forage halophytes such as *Kochia scoparia*, *Atriplex nitens*, *Climacoptera lanata*, *Glycyrrhiza glabra* and others. The report contains test results of perspective types of forage crops and halophytes in conditions of sandy Kyzylkum desert at irrigation with thermal, mineralized artesian waters.

6.6.2 Materials and methods

6.6.2.1 Experimental site location

988. Kyzylkum site is located 150 km northwest of Navoi city, in the territory of Kanimeh district in shirkat farm of Madaniyat (Figure 131). The experimental site is located in the region, which is referred to as 'Kyzyl-Kesek'. Shirkat farm "Madaniyat" is a typical farm in Kyzylkum region, which primary activity is targeted to deserted animal production, in particular karakulsheep, camel, horse breeding. The experiments connected with irrigated fodder production were conducted at the same farm at Kyzylkesek site, at the altitude of 125-190 m above sea level.

989. At this site, previously intensive research experiments have been conducted under the supervision of ICBA (International Center for Biosaline Agriculture). Partly, the experiments from their research project were continued in the frame of the SLMR project.

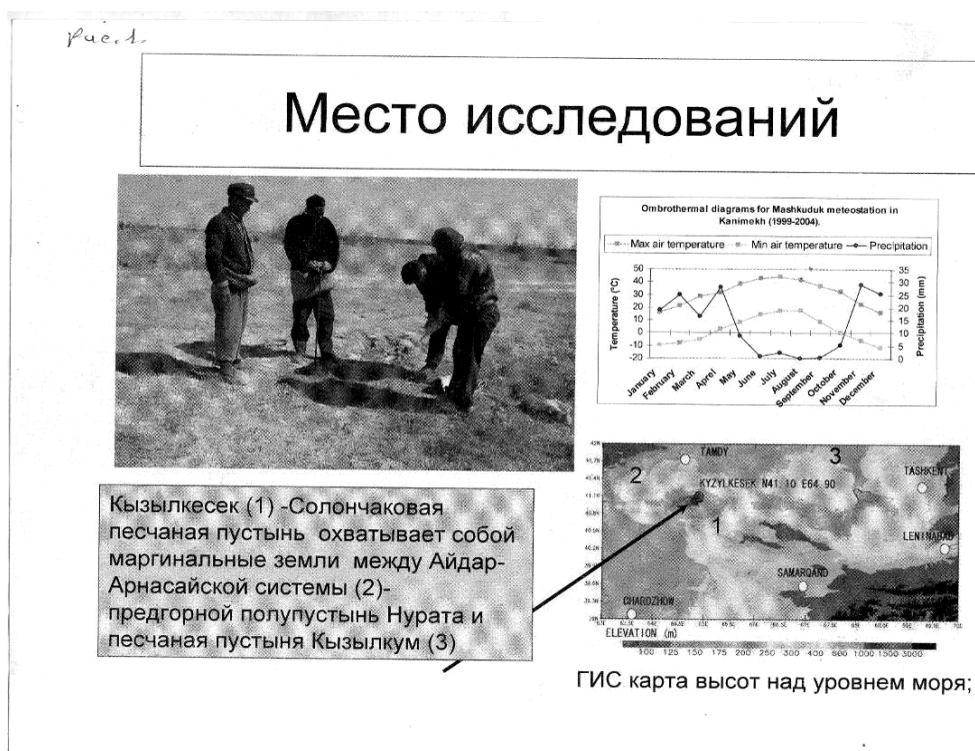


Figure 131. Experimental site in Kyzylkum

6.6.2.2 Climate

990. The experimental site has sharp continental climate with the highest air temperature of +44°C during July, so very hot summers. The air temperature declines to as low as -20°C to -22°C during winter months. The mean annual temperature is 14°C with the long-term annual precipitation of 140 mm. The wet periods of year are fall-winter and early-spring (November-May).

6.6.2.3 Soil-climatic conditions of experimental site

991. Relief and soil-ground conditions of sandy desert differ by mixed character and complexity. Overgrown and not movable forms of relief as raised-beds and bumps of different heights alternate with active sands as barchans and barchans chains.

992. Sites with very cut relief combined with flat areas. Takyr and takyr like soils can be met together with sandy and sandy-loamy soils. Also there are sandy sites with small bumpy sands which are combined with typically grey-brown soils.

993. Soils of sandy deserts in comparison with other types of soils and especially of gypsum desert have relatively favorable water physical features for plants' vital functions: high permeability and aeration, less salinity. Precipitations in spite of their small amount penetrate to a very big depth and better used by plants. This fact determines a big diversity of rangelands botanical content, their usage in almost all seasons. At the same time sandy soils due to the

impact of various negative anthropogenic factors easily can be broken and obtain mobility that leads to their degradation.

994. Agro-chemical rates of the experimental site are as follows: humus content – 0.22-0.97% (=low productive), almost no content of mobile nitrogen, phosphorous content - 325-725 mg kg⁻¹ at the 1.20 m soil profile (Table 173).

Table 173. Soil agrochemical parameters at the experimental site

Soil depth, cm	Nutrients contents in the soil			
	%	mg/kr		
	Humus	N	P	K
Natural degraded saline pasture				
0-5	0.67	Abs	925	23437.5
5-20	0.42	3.75	750	25000.0
20-40	0.38	Abs	550	25000.0
40-60	0.26	Abs	550	23437.5
60-80	0.11	Abs	525	23529.4
80-100	0.52	Abs	625	26760.6
100-120	0.22	1.5	700	25880.3
Experimental site				
0-20	0.97	37.75	725	25000.0
20-40	0.57	Abs	650	25000.0
40-60	0.26	1	325	25000.0
60-80	0.22	1.5	500	21666.7
80-100	0.52	Abs	550	20588.2
100-120	0.42	1	500	20588.2

6.6.2.4 Chemical composition of irrigation and drainage water

995. Monitoring the fluctuation of groundwater level reveals that water level was in the range of 1.20-1.40 m over the crop season.

996. Irrigation water is moderately saline with constant water temperature of 40°C, pH=7.4. The salinity level in groundwater as represented by EC_{gw} was 8.3 dS m⁻¹. The concentrations of cations Ca²⁺, Mg²⁺ and Na⁺ were 9.49 mmol_c L⁻¹, 7.7 mmol_c L⁻¹ and 25.46 mmol_c L⁻¹, respectively (Table 174).

Table 174. Chemical composition of artesian (irrigation) and drainage water

Samples	Dates	Chemical composition										
		pH	Ec	TDS	Soluble cations*				Soluble anions*			
					Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	SAR**
					mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹
dS m ⁻¹	Mg L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹	mmol _c L ⁻¹		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Drainage water (1)	10.08.06	7.93	10.92	8800	29.16	30	77.32	0.18	4.4	56.31	76.95	14.22
Drainage water (2)	10.08.06	7.85	12.78	8750	28.66	29	77.78	0.18	4.3	56.31	75.11	14.49
Drainage water (3)	10.08.06	8.1	9.49	9000	29.56	30.5	77.26	0.18	4.3	61.95	76.98	14.10
Well (1)	10.08.06	7.4	5.6	2654	9.19	7.5	24.57	0.2	2.9	17.52	21.12	8.51
Well (2)	10.08.06	7.3	7.1	2716	9.19	7	24.97	0.2	2.7	17.52	21.2	8.78
Well (3)	10.08.06	7.4	8.3	2826	9.49	7.7	25.46	0.2	2.9	17.52	22.46	8.68

6.6.2.5 Experimental crops and plants

997. For the purpose of land and water resources rational usage we selected the most precious types of forage plants of high productivity, salinity and heat resistance. The best alfalfa varieties of domestic selection (Tashkentskaya - 3192) and representatives of foreign varieties; Eureka and Scepter (seeds were taken from ICBA) were used in the tests. The following cereal crops were planted: wheat, barley, rye, triticale, various varieties of millet and sorghum (seeds from ICARDA) and local varieties: sorghum (white maize, broomcorn, Sudan grass) and perspective samples of millet, seeds of which also were taken from ICARDA.

998. Some perspective varieties of forage halophytes also were tested: *Kochia scoparia*, *Atriplex nitens*, *Climacoptera lanata*, *Glycyrrhiza glabra*. Experiments were carried out for cultivating melon, watermelon and cucurbit in order to get information about possibility of cultivating the vegetable and watermelon crops in given soil-climatic conditions.

6.6.2.6 Growing conditions

999. As it was pointed out above soils of the experimental site are low fertile. In this relation before implementing the experiment 15-20 t ha⁻¹ of sheep manure were applied to the soil (before plowing). Additional application of urea fertilizer of 150 kg ha⁻¹ was carried out during vegetation period.

6.6.2.7 Rate and frequency of irrigation

1000. Discharge of the artesian well is 13 l s⁻¹. Irrigation rate of experimental plots has been made 600 m³ ha⁻¹ every time. Frequency of irrigation is 1-2 times depending on the crop's variety in May, each decade - June, July and 1-2 times in August. For the whole vegetation period 6-10 irrigations were carried out, with a total water application rate of 3600-6000 m³ ha⁻¹.

1001. Rangelands monitoring was carried out by the determination of type content of plant cover, accompanied by herbarium collection. Rangelands productivity was determined by transect method at different space from the sheep pond source. Testing of different types of forage plants was carried out at the experimental plots of 25-30 m² size in three replications.

1002. Types and samples were evaluated according to the following characteristics:

- Growth and development;
- Phenology;
- Survival rate;
- Yield of seeds forage mass.

1003. Dynamics of growth was determined by plant measurement from root crown to the height point by measuring bar, 25 plants were measured from each replication. Phenological observations were carried out according to Beydman method (1960);

- Survival rate of plants is determined by the calculation of plant density in the experimental plots;
- Yield of forage weight and seeds was determined by the entire cutting of the top and the seeds by threshing the blossom clusters;
- Chemical composition and nutritive value of forages were assessed at the central analytical laboratory of UzSRIKBDE according to the conventional methods (Lebedev, Usovich, 1965).

1004. In order to save the irrigation water were used flexible pipes with 200 mm diameter, made of plastic films and chutes which were worked out and produced by SANII (R. Ikramov).

6.6.3 Results of the experiments

6.6.3.1 Experiment 1. Testing of winter cereal crops

1005. Wheat, barley, triticale, rye, sorghum, maize, millet participated in the tests. Grain crops planting was carried out in the third decade of September. Sheep manure was applied to the soil in calculation of 20 t ha⁻¹ before planting, soil plowing was done to 25-30 cm depth with harrowing.

1006. Seeds were planted manually by the broadcast method. Harrowing was carried out in order to place seeds into the soil. Seed rate is 200 kg ha⁻¹. Irrigation furrows were cut with 60 cm wide raised-beds after planting and harrowing. First irrigation was done after the planting and in 10 days good and even sprouts came up.

1007. Intensive plant growth was observed in spring. During the booting stage Urea was applied in calculations of 150 kg ha⁻¹ of physical weight. In such growing conditions height of plants before barley (variety mavlono) harvesting has been made 40-45 cm, rye - 80-90 cm, triticale - 88-93 cm and wheat (variety kroschka) - 46-50cm.

1008. In experiment conditions yield of air-dry barley biomass has been made 5.01±0.12 t ha⁻¹, rye – 4.83±0.17 t ha⁻¹, triticale 3.01 t ha⁻¹ and wheat – 3.05±0.17 t ha⁻¹ (Table 175).

1009. From the Table 175 it is obvious that barley and rye should be cultivated in the given conditions in order to get fodder mass. These crops give approximately 50 centner of hay from each hectare. Potential seed productivity of the grains has been made 1.6-2.6 t ha⁻¹, the highest yield was formed by triticale. Unfortunately, real grain yield could not be determined as during the milkstage the entire yield was eaten by birds.

1010. Thus, conclusion can be done from the experiment of grain cultivation that in Kyzylkum conditions at small scale irrigation agriculture, grains can be cultivated only for hay production for cattle wintering.

Table 175. Winter grain crops productivity with irrigation by artesian thermal mineralized waters of Kyzylkum (Kyzylsek, 2007).

Type, variety	Density of plants,	Height of plants,	Dry biomass,	Yield of grain*
---------------	--------------------	-------------------	--------------	-----------------

	thous. ha ⁻¹	cm.	centner ha ⁻¹	centner ha ⁻¹ .
Barley "Mavlono"	292.2±17.6	41.4±5.6	50.1±1.2	20.1±0.6
Rye "Kyrgyzskaya-1"	307.8±10.1	88.6±5.2	48.3±1.7	17.0±0.3
Triticale "Prag serebristiy"	247.8±8.6	88.4±5.4	30.1±1.3	26.1±0.7
Wheat "Kroshka"	285.6±7.2	45.4±4.2	30.5±0.7	16.3±0.3

6.6.3.2 Experiment 2. Testing of maize, sorghum, millet and Sudan grass varieties

1011. As the main problem is a feed production for cattle then probably testing of high productive forage crops as maize, sorghum and millet can be of a great interest. These crops are heat-tolerant plants and usually they are planted in April.

1012. Maize is a crop of manifold usage and has a high productivity. Grain of maize is a perfect fodder for all types of domestic animals and birds. One kilogram of maize grain by its nutritiousness is equal to 1.34 fodder unit containing 78 g of digestible protein. As silo crop maize takes the first place, 100 kg of maize hay for its nutritiousness is equal to 37, and 100 kg of milled stems are equal to 35 fodder units. Two maize yields can be obtained per one year in Kyzylkum conditions.

1013. Another high productive crop is millet. High fodder advantage has millet hay – 51 fodder unit. By quality it is close to middle hay. Millet is one of the drought-resistant, heat-tolerant and salt-resistant crop. Sorghum also can be used in many ways. In the stems of sorghum sugar varieties, sugar content reaches to 15%. There are data that in the irrigated zones yield of sorghum land mass reaches to 1000 centner ha⁻¹.

1014. To grow high feed productivity maize, millet and sorghum require good soil fertility. Due to this we cultivate these crops in the growing conditions of: 20 t ha⁻¹ of manure, 2 centner ha⁻¹ of ammonium phosphate, 130 kg ha⁻¹ of urea, 1.0 centner ha⁻¹ of calcium fertilizers. In such growing conditions yield of maize green biomass was 48.4 t ha⁻¹, millet - 78.0 t ha⁻¹, sorghum - 50.3 t ha⁻¹ (Table 176).

1015. Unlike millet and sorghum maize does not suffer from birds and at the end of vegetation we managed to harvest 2.7 centner ha⁻¹ of grain. Blossom clusters should be covered with coarse calico sacs for obtaining the seeds of millet and sorghum. The best terms for isolating the blossom clusters of sorghum and millet is a flowering stage.

Table 176. Feed productivity of some varieties of maize, millet and sorghum in Kyzylkum conditions (Kyzylsek, 2008-2009)

Type, variety	2008	2009				
	Density of plants,	Height, cm.	Yield of green mass,	Density of plants,	Height, cm.	Yield of green mass,

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	thous. ha ⁻¹		centner ha ⁻¹	thous. ha ⁻¹		centner ha ⁻¹
Maize "Belozubnaya"	89.1±4.5	162.4± 5.8	484.3±5.1	96.1±2.4	124.6±5.3	-
Millet "Aip 13150" (ICARDA)	70.0±0.2	176.3±4.8	780.6±3.6	86.3±3.2	125.8±4.4	-
Sorghum "Ok Jukhory"	34.2±0.4	158.6±4.4	490.7±1.9	57.8±4.6	117.8±7.3	-
Sorghum "Venichnaya" 623"	81.6±4.8	146.3±3.6	503.7±6.2	93.4±3.6	113.6±3.6	-
Sudan grass	-	-	-	108.6±4.3	165.1±4.1	897.3±2.1



Figure 132. Measuring maize height before irrigation with plastic chutes



Figure 133. Sorghum growing in the field



Figure 134. Sudan grass growing in the field

1016. Data from the Table 176 show that cultivation of maize, sorghum and millet stipulates to get 50.0-80.0 t from one hectare of high nutritious, vitamin fodder in Kyzylkum that is very important for this region. Yield rates of these crops in 2009 have not presented yet because at present time the plants are in the vegetation stage.

1017. The most perspective plant for green mass and hay production was Sudan grass. We have tested this crop since 2009. In experiment conditions height of Sudan grass at the stage of full panicle has been made 165.1 ± 4.1 cm, yield of green mass – 89.73 ± 0.21 t ha⁻¹, and yield of hay – 19.20 ± 0.29 t ha⁻¹ (Table 176.). Sudan grass can be cut twice per year. Taking this into account we can say that this crop is more perspective for hay production then maize, millet and sorghum.

6.6.3.3 Experiment 3. Experiment of cultivating legumes fodder crops

1018. Alfalfa takes a special place among fodder plants of the legumes family. At harvesting for hay during booting stage dry mass contains 21.9% of protein, and at the flowering stage – 16.8%. One kilogram of hay is equal to 0.48 fodder unit and contains 10.4 g of lysine. Alfalfa crops prevent the repeated salinity that is very important for our conditions where irrigation water and soil are very saline. In the irrigated zones of Uzbekistan yield of alfalfa hay reaches 140-150 centner ha⁻¹. Alfalfa needs fertiliation that is why its growing conditions included 20 t ha⁻¹ of manure, 60 kg ha⁻¹ of ammonium phophate, 20 kg ha⁻¹ of calcium fertilizer.

Dates of planting

1019. In Kyzylkum conditions alfalfa can be planted at two dates: in spring (March) and at the end of summer (August). At both dates irrigation should be done before seeds sowing in order to speed up germination.

1020. Research results of different types of alfalfa indicate the perspective of Tashkentskaya 3192 variety. In the nursery gardens of competitive variety testing of alfalfa in 2007 the following varieties were tested: Tashkentskaya 3192 (st), Eureca, sceptre, D-1 and D-2 seeds of which were taken from ICBA. Yield rates of these crops are presented in the Table 177.

Table 177. Yield of different alfalfa varieties in competitive variety testing of the crops in 2007. (Kyzylsek, 2007-2009)

Varieties	Hay yield for 4 cuttings, centner ha ⁻¹ .		
	2007*	2008	2009**
Tashkentskaya - 3192(st)	86.4	144.5	69.0
Eureca	72.3	97.8	59.0
Sceptre	63.6	86.3	51.3
D-1	64.3	78.4	48.4
D-2	62.6	76.6	41.2

*The results of this experiment in part have to be accredited to the work of ICBA under Dr. Kristina Toderich until 2007 whose experiments were extended in the frame of the SLMR project.

**overall for 2 cuttings.



Figure 135. One-year old alfalfa field



Figure 136. Alfalfa after 3 years

1021. Mass germination was observed in 5-6 days after the irrigation. Method of planting is manual with broadcast method. Seed rate is 15 kg ha^{-1} . Intervals between irrigations have been made 10-15 days during the period of re-growth and 8-10 days during its intensive growing. Maximum productivity alfalfa began to show during the third year of growing. Five cuttings were carried out in Kyzylkum conditions: 1st cutting in May, 2nd cutting in June, 3rd cutting in July, 4th in August and 5th in September. Autumn re-growth was observed after 5th cutting. In October height of grass has been made 20 cm, fodder mass of which was used as pasturage.

1022. Table 178 contains productivity data of alfalfa hay (Tashkentskaya – 3192) according to the cuttings. High productivity rates of Tashkentskaya-3192 variety from our point of view can be explained by good adaptation of variety to the environmental conditions. Thus, cultivation of alfalfa Tashkentskaya-3192 variety allows achieving hay yields of $14.0\text{-}15.0 \text{ t ha}^{-1}$ from each hectare of irrigated land.

Table 178. Productivity of alfalfa Tashkentskaya–3192 in Kyzylkum conditions

Variety	Hay yield from cuttings, centner ha ⁻¹					Totally for 5 cuttings
	1	2	3	4	5	
	22.6±0.9	30.5±1.3	30.1±1.9	29.3±2.1	26.3±1.2	144.5

1023. Another perspective fodder plant of legumes family is licorice (*Glyzerriza Solodka golaya*). In nature licorice is widely spread in the valleys of rivers, lakes, in tugai forest, in brackish fallow lands. It is forage, officinal, tinctorial, melliferous, alconide, essential oil, paper, fibrous, saponin, coumarin and noxious plant.

1024. Licorice is well-eaten by cattle in autumn and winter (Figure 137). And hay plant is highly appreciated as a fodder. Licorice seeds are hard, field germination is low. In this relation licorice multiplication is carried out by root cutting.

1025. Root cuttings at 12-15 cm length are prepared for licorice planting. Soil tillage includes under-winter ploughing to 25-30 cm depth and harrowing. After harrowing irrigation furrows are cut at 60 cm raised-beds and ten cuttings are planted to 15-20 cm depth.

1026. Space between cuttings is 60 cm. Rate of cuttings per 1 ha is 25-27 thousand pieces. In May 1-2 shoots grow from each cutting. In our experiments at the end of 1st vegetation licorice density has been made 27-28 thousand pieces ha⁻¹, in the second year - 57000 pieces ha⁻¹ and in the third - 62 thousand pieces ha⁻¹. Reproductive stage of plants begins in the first year (68%).

1027. Maximum productivity licorice shows in the third year of growing. Height of three-years plants reaches 120-130 cm (Table 179).

1028. Growing conditions of licorice formed for the account of applied organic fertilizers (sheep manure of 15-20 t ha⁻¹). Irrigation regime is in every decade during the period of intensive growth (June-July) with irrigation rate of 800 m³ ha⁻¹.

Table 179. Some important rates of licorice in Kyzylkum conditions

Vegetation year	Density of plants, thous. pieces ha ⁻¹	Height of plants, cm.	Yield of surface biomass (green) centner ha ⁻¹
1 st 2006	26.8±3.2	76.8±2.1	126.1±1.8
2 nd 2007	52.7±6.3	96.7±3.6	193.2±2.6
3 rd 2008	62.1±3.4	126.7±3.9	236.4±3.8



Figure 137. Licorice in the field

1029. Thus cultivation of licorice in conditions of irrigation lands in Kyzylkum allows producing up to 24.0 t ha⁻¹ of green mass from each hectare. Licorice rootstock is of huge demand even at the domestic market of Uzbekistan. In this relation licorice can be a good source for additional income for people living in the Kyzylkum desert.

6.6.3.4 Experiment 4. Testing of fodder types of halophytes

1030. Halophytes are the most stable types for substrate and irrigation water salinity. Especially actual is to test halophytes under the conditions of irrigation lands of Kyzylkum when soil and irrigation water are considerably saline. For the last 15-20 years wide-ranging complex Research have been carried out for studying halophytes in Israel, USA, Mexico, north Africa and in other countries. More than 120 types of halophytes have been studied, more than 20 perspective types for feed production were found out. Research results of a number of chenopodiaceous representatives enabled to find out some perspective types of halophytes which can be adapted to the saline waters and can intensify feed production in Kyzylkum conditions.

1031. Mock cypress – *Kochia scoparia*, seepweed high – *Suaecda altissima*, batter tree - *Bassia hissofolia*, Atriplex nitens can be referred to them. Advantages of *Climacoptera lanata* are determined for feed production without irrigation.

Phenology of halophytes

1032. In the crops of winter season (January) germination of Atriplex nitens is observed in the middle of April and germination of other types (*Suaecda altissima*, *Bassia hissofolia*, *Climacoptera lanata*) was recorded for 5-7 days earlier, i.e. on 7-10 April (Table 180)

Table 180. Phenology of fodder halophytes in Kyzylkum conditions

Type	Germination	Branching	Booting	Flowering	Fruiting	Ripening
<i>Kochia scoparia</i>	8.04	5.05	25.05	20.06	12.08	15.09
<i>Atriplex nitens</i>	15.04	5.05	25.05	20.06	12.08	15.09
<i>Bassia hissofolia</i>	8.04	5.05	25.05	20.06	12.08	15.09
<i>Suaecda altissima</i>	8.04	5.05	25.05	20.06	12.08	15.09
<i>Climacoptera lanata</i>	8.04	5.05	25.05	10.07	12.08	17.10

1033. Branching stage of all testing types starts almost at the same time - at the beginning of May, flowering - in June-July, fruiting - in August. Ripening of *Kochia scoparia*, *Atriplex nitens*, *Bassia hissofolia* and *Suaecda altissima* started in the middle of September and of *Climacoptera lanata* – in the middle of October.

Growth, development and feed productivity

1034. Tested types of halophytes differed by quite high survival rate. If plants density of different types varied in spring at the range of 27.8-97.2 thous. pieces ha⁻¹, in autumn this rate has been made 20.0-92.4 thousand pieces ha⁻¹, i.e. survival rate of different types has been made

from 71.9 to 96.6%. Together with this the lowest survival rate was observed in *Climacoptera lanata* (71.9%), the highest in *Bassia hisopofolia* 96.6% (Table 181).

1035. The highest fodder productivity had mock cypress ($90.7 \text{ centner ha}^{-1}$) (Table 181). Yield of halophytes seeds is quite high - 12-16 centner ha^{-1} , that is very important for feeding animals. Total biomass of *Climacoptera lanata* even without irrigation reaches to 50 c of dry mass.

Table 181. Some important rates of fodder halophytes in crops conditions, Kyzylsek, 2008.

Type	Density of plants, thous. piecesha-1		Height of plants, cm.	Yield, centner ha-1.	
	in spring	in autumn		hay	seeds
<i>Bassia hisopofolia</i>	47.0 ± 0.7 100	45.4 ± 0.9 96.6	121.4 \pm 3.2	64.7 \pm 3.6	12.6 \pm 4.1
<i>Kochia scoparia</i>	95.0 ± 2.8 100	90.0 ± 0.9 94.7	127.4 \pm 3.3	90.7 \pm 3.9	16.0 \pm 3.2
<i>Suaecda altissima</i>	45.7 ± 2.7 100	39.0 ± 1.9 85.3	140.0 \pm 4.1	47.0 \pm 2.7	3.8 \pm 2.1
<i>Climacoptera lanata</i> (without irrigation)	27.8 ± 1.3 100	20.0 ± 1.0 71.9	57.4 \pm 1.9	35.4 \pm 3.1	14.1 \pm 3.2



Figure 138. *Kochia* and *Suaecda* plants



Figure 139. *Climacoptera* plants



Figure 140. *Atriplex nitens* plants

1036. As far as fodder types of halophytes are the representatives of wild flora, it is very important to study their chemical composition, fodder quality and eating them by agricultural animals. Analysis carried out in the central analytical laboratory of UzSRIKBDE shows that protein content on fodder mass of mock cypress and Suaecda altissima almost in 2 times more than of Atriplex nitens and Climacoptera lanata. Content of raw fat is also higher in these types - 3.56 and 4.2% respectively (Table 182). Climacoptera lanata contains the highest percent of raw cellulose (38%) and ashy matters (218%).

Table 182. Chemical composition (%) of fodder halophytes (flowering stage)

Variety	Raw protein	Raw fat	Raw cellulose	BEV	Ash
<i>Kochia scoparia</i>	17.21	3.56	29.67	33.89	15.79
<i>Atriplex nitens</i>	9.0	1.47	31.6	47.1	10.5
<i>Suaecda altissima</i>	20.9	4.2	23.3	32.3	19.2
<i>Climacoptera lanata</i>	10.7	2.55	38.0	47.3	21.8

Nutritive value and eating

1037. Testing types of halophytes according to their nutritive value do not yield to the main types of pasturable plants. Hay of *Climacoptera lanata* contains 0.50 fodder units and hay of *Suaecda altissima* - 0.79. The largest amount of digestible protein was observed in the hay of *Suaecda altissima* - 75 g/kg, the smallest in the hay of *Kochia scoparia* - 25.0 g/kg (Table 183).

1038. Results of studying the halophytes eating by karakul sheep showed that hay of *Atriplex nitens*, *Kochia scoparia*, *Bassia hisopofolia* and *Suaecda altissima* was eaten quite well (55-77.3%) and satisfactory.

Table 183. Nutritive value of halophytes.

Type	Development stage	Gross energy, kkal.	Exchange energy, MOJ	Fodder units	Digestible protein, g/kg
<i>Kochia scoparia</i>	Flowering	17.37	8.12	0.53	25.0
<i>Atriplex nitens</i>	Flowering	16.57	8.47	0.57	42.0
<i>Suaecda altissima</i>	Flowering	40.14	8.70	0.68	45.0
<i>Climacoptera lanata</i>	Flowering	39.59	9.88	0.79	75.0
<i>Bassia hisopofolia</i>	Flowering	44.19	7.85	0.50	55.0
Pasture forage	Flowering	43.1	7.61	0.48	27.8

1039. But *Climacoptera lanata* was not eaten well, i.e. only 16.0%. It is known that *Climacoptera lanata* collects up to 40% of salts in biomass. In our opinion exactly for this reason it was eaten less. After leaching with warm water, eating of *Climacoptera lanata* increased to 79.13% (Table 184).

1040. Thus, leaching of halophyte fodder before feeding is an effective activity for increasing eating rates. Together with high feed production (50-100 centner ha⁻¹ of hay) and good nutritive value (0.48-0.79 fodder units), halophytes have one more very important peculiarity - to accumulate salts in their organisms that tells about bioreclamation abilities of these types.

Table 184. Halophytes eating (%) by karakul sheep

Type	Number of tested animals	Amount of fodder, kg.	Amount of not eaten fodder, kg	% of eating	% of not eaten fodder
<i>Kochia scoparia</i>	10	15	5.3	64.67	35.3
<i>Bassia hissofolia</i>	10	15	6.5	56.7	43.3
<i>Atriplex nitens</i>	10	15	3.4	77.3	22.7
<i>Suaecda altissima</i>	10	15	6.7	55.0	45.0
<i>Climacoptera lanata</i>	10	15	12.6	16.0	84.0
After leaching with warm water	10	15	3.13	79.13	20.87

6.6.3.5 Experiment 5. Experiment of cultivating watermelons

1041. Role of watermelon crops in nutrient security of local population in desert is huge as the source of vitamins, sugar and other important components of rational nutrition. “Is it possible to produce these important foodstuffs in local conditions?” Coming out from the carried out Research we can say - yes!

1042. Watermelons such as melon, watermelon, and cucurbit nicely react to the fertile soil. In this relation application of organic and mineral fertilizers is required while cultivating these crops in Kyzylkum’s conditions. Combined fertilizers’ application is of more effect. Sheep manure at a rate of 15-20 t ha⁻¹ was applied under melon and watermelon and 30-40 t ha⁻¹ was applied under the cucurbit as organic fertilizers. Application of higher dosage for these crops is not desirable because they can delay fruits’ ripening and impair their quality. Together with organic fertilizers were applied mineral fertilizers: N90 P135 K60 per 1 ha. At planting (in May) N10 P15K10 per 1 ha to the bed. Additional application (at flowering stage) of fertilizer at the rate of N30 P45 K45 per 1 ha was carried out during vegetation.

1043. Planting of watermelons was carried out on 10-11 May and planting of pumpkins on 20 May. Vegetation period of these crops in Kyzylkum’s condition has been made: for pumpkin (cucurbit), watermelon and melon - 150-155 days, for khandalyak - 75 days. Mass ripeness of melon was observed on 10 August, khandalyak ripened at the beginning of June.

1044. Yield measuring of watermelon showed that under such growing conditions is possible to obtain fruits of watermelon – 32.4 t ha⁻¹, melon – 30.0 t ha⁻¹, khandalyak – 21.0 t ha⁻¹, cucurbit – 20.0 t ha⁻¹ for selling (Table 185). Fruits of watermelons were of huge demand and farmer sold his products at a price of 500 soum per 1 kg. Besides watermelons, farmer cultivated tomatoes for family needs, yield of which has been made 28.0 ± 4.3 t ha⁻¹.

Table 185. Yield of watermelons at Kyzylkum experimental site.

Type of crop	Yield of fruits, t ha-1
Cucurbit	20.0 ± 4.1
Watermelon	32.4 ± 4.0
Melon	30 ± 4.3
Khandalyak	21.0 ± 2.4
Tomato	28.0 ± 4.3

1045. Thus, results of our experiments show that in Kyzylkum conditions it is possible to cultivate successfully not only fodder crops, but also watermelon and vegetable crops using mineralized artesian waters.

6.6.3.6 Economical rates of irrigation agriculture in Kyzylkums.

1046. Our preliminary calculations indicate that irrigation agriculture in Kyzylkum is economically profitable activity which provides the employment for population, creates the forage resources for cattle wintering, creates conditions for nutrient security of population, and reveals additional sources of income for population.

1047. Costs for cultivation technologies of different crops include the followings: costs for soil tillage, attendance of crops, seeds etc. depending on crop's types which have been made from 250000 to 585000 soum ha⁻¹. Cost of produced products has been made from 1040000 to 4400000 soum ha⁻¹. At the same time net income from each hectare has been made from 455000 to 3840000 soum (Table 186).

6.6.4 Discussion

1048. Experiment for arranging the irrigation foraging in Kyzylkum desert indicates about the availability of huge potential for strengthening the forage resources of desert livestock production. Artesian wells can serve as the main sources of irrigation water, water discharge of each well is made in average 10-15 l/s, that can supply irrigation livestock production for 5-6 ha. Only in Kenimekh district such artesian wells number is more then 60. These water sources are self filled and do not require investments for taking water to the land's surface. Almost all of them at present time run free, watering considerable areas.

1049. Research that we carried out indicate about perspective of cultivating maize, sorghum, millet, alfalfa, rye, barley, licerice. From watermelon crops 20-30 t of products can be obtained for selling, which are of high flavoring quality. At high saline sites can be successfully cultivated fodder halophytes which enable to produce 50-100 centners of hay from each hectare.

Table 186. Economic rates of cultivating fodder crops at Kyzylkum experimental site.

Type of plants	Seeds	Costs for agrotechnique				Total costs for technique	Yield t ha-1	Cost for 1 kh of hay, soum	Total cost for hay, soum	Net income soum
		Plowing	Planting	Attendance	Fertilizer					
Kochia scoparia	5 kg 25000	150000	50000	150000	60000	435000	7.3	200 s	1460000	1025000
Atriplex nitens	15 kg ha-1 75000	150000	50000	250000	60000	585000	5.2	200 s	1040000	455000
Licerice 1 st vegetation year	2000000	150000	100000	250000	-	2500000	1.3	300 s	390000	2110000
Licerice 3 rd vegetation year	-	-	-	250000	-	250000	13	300	3900000	3650000
Millet (seeds biomass)	30 kg ha-1	150000	50000	150000	60000	560000	22	200	4400000	3840000
							5.1	500	2550000	1990000
Sudan grass (seeds)	40 kg ha-1 120000	150000	50000	150000	60000	530000	5.7	300	1710000	118000
							3.5	500	1750000	1220000
Maize (silo) seeds	70 kg ha-1 <u>140000</u> 60000	150000	50000	150000	60000	500000	9.0	200	1800000	1300000
		15000	50000	150000	60000	470000	6.8	500	3400000	2930000
Sorghum (silo) seeds	30 kg ha-1 150000 10 kg 50000	150000	50000	15000	60000	560000	6.3	300	1890000	1330000
		150000	50000	15000	60000	460000	3.5	500	1750000	1290000

1050. Cultivation of winter grain crops (barley, rye, triticale, wheat) allows producing aboveground biomass of 30-150 t from each hectare.

1051. Maize, sorghum, millet can form yield with 48-75 t of silo mass, alfalfa -can form 140-150 centners of hay. Double income source can be taken from licorice, aboveground biomass as fodder, rootstock as industrial raw material.

1052. The seminar-training held at the territory of Kyzylkum experimental site (August, 2008) caused a great interest of specialists, farmers and local population.

1053. At present time areas of irrigated agriculture in the region are increasing. Locals have already begun to cultivate alfalfa, sorghum, maize, watermelon, melon and cucurbit. In shirkat farm "Madaniyat" areas with alfalfa crops in 2009 were reached to 2 ha, areas of watermelons to 5.0 ha.

6.6.5 Conclusions

1. Self filled artesian wells with thermal and mineralized water can become the source of irrigation water for arranging the irrigation agriculture in Kyzylkums.
2. Organic and mineral fertilizers: 15-20 t ha⁻¹ of sheep manure, N150P90-120K60 should be applied in order to get high yield of hay and other products.

At cultivating watermelons additional treatment is needed: N30P20K10.

3. Cultivation of winter grains enables to get 3-5 tons of hay from each hectare. Grain yield is totally eaten by birds.
4. Cultivation of maize, sorghum and millet enables to get 48-78 tons of silo mass from each hectare;
5. In Kyzylkum conditions hay yield of alfalfa can reach to 144-150 centner ha⁻¹;
6. licorice can serve as source for double income: over-ground mass as fodder, rootstock as raw material for pharmaceutical industry. Yield of licorice can reach 23 t ha⁻¹ of hay.
7. By cultivating halophytes: kochia scoparia, Bassia hisopofolia, Suaecda altissima, Atriplex nitens and Climacoptera lanata in conditions of saline substrate and irrigation water 5.0-10.0 tons of hay with good nutrients can be obtained from one hectare.
8. Cultivation of watermelons (watermelon, melon, cucurbit) under the high growing conditions enables to obtain 20-30 tons of products from each hectare.
9. Organization of irrigation agriculture in Kyzylkum's condition with using the artesian mineralized water is economically profitable activity which enables to obtain up to 4.5 million soum net income from each hectare.

6.6.6 Necessary Research to be carried out in future

1054. Organization of irrigation agriculture in conditions of sandy Kyzylkum desert with using artesian mineralized water turned out to be economically profitable activity and successful in our experiments.

1055. Probably these issues require complex approach and additional Research should be carried out in order to solve many problems.

1056. How will be a water-salt regime in the soil in future? Role of halophyte in bio reclamation and soil layering, their place in the crop rotation, problem of irrigation water saving, organization of drainage systems, effective techniques of machines for cultivating various crops etc. Besides that an important role plays the Research related to the selection of the most salt-tolerant, heat-resistant, drought-resistant types and varieties of fodder, grain, fruit and vegetables and watermelon crops.

6.7 Uzbekistan: Activity 5. Calibration and use of optical sensor for crop biomass evaluation, Nitrogen

6.7.1 Introduction

1057. Uzbekistan is an agrarian country with favourable soil and climatic conditions for producing 2 to 3 crops per year. Earlier long-term investigations related to produce cotton crop did not anticipate getting 2 crops per year. Issues related to ensuring the population food security made little corrections in the land husbandry system. Today, cotton planted area make up 1.5 million ha, while that under irrigated cereal crops is 1 million ha. However, irrigated lands area is limited, while more favourable no saline lands occupy half of the total area.

1058. Uzbekistan population is increasing from year to year and food safety is more of a hot-button issue. There is need to develop crop production technology with minimizing all processes of crop production under low technical supply, water and fertilizer deficit, which will allow to produce 2 crops per year, in particularly cotton + grain per one field.

1059. At the same time, there are not enough scientific studies on optimum dates of mineral fertilizers applications depending on biomass accumulation in irrigated lands, particularly; the study with involving Greenseeker instrument application is being implemented first time.

6.7.2 Experimental site description

6.7.2.1 Soil conditions

1060. This on-farm study was carried out during the years 2007-2009 in experimental plot of Uzbek Cotton Research Institute in Tashkent province of Uzbekistan. The study site was in the right bank of the Chirchik River, at 8-10 km far from the river. It is located in the center of submountain slopes of south-western flanks of Karjan-tau Mountains; constituent in Chatkal mountain ridge, 576 m above sea level (Farmer fields are located nearby, under same conditions).

1061. Experimental site area is located in typical sierozem zone and majority area is represented by typical sierozems with deep groundwater level (18-20 m). Majority of the experimental site area is a plain which is subjected to irrigation erosion. The soils are heavy loamy and silty clay. The greater part of farmlands located in old irrigated, sierozem soils eroded and hydraulically washed by residuals. The humus horizon is 70-80 cm. Carbonate strata are found on depths below 1 m in the form of mold. Soil chemical composition (according to Maltsev I.M.): Nitrogen content is 0.08-0.11%, Phosphorous is 0.14-0.22%, potassium is 1.82-2.44%, and Organic matter is 0.9-1.5% at 0-25 cm soil depth.

1062. Under current farming practices, due to higher soil biogenetic capacity, it was not succeeded to enrich Organic matter content at the higher soil horizons, even under deep bedding

in the plant residues. The soils of the area have higher salinity of organic matter and concentrated nitrogenous matters.

1063. Amount of mobile phosphorous forms depends on amount of fertilizer application and farming practices, and predecessor-crop. At the same time the soil of the Institute and nearby farmers' fields belongs to moderate and highly provided with P, while concentration of mobile K is low and moderate.

6.7.2.2 Climate

1064. Experimental site occupy northern-easternmost part of semi desert area and northern-easternst region of cotton planting zone. The climate is continental. The weather conditions are favorable for cotton and other crops growing. No frost period is 210-216 days; number of sunny hours per year is 2692-2870 days. Precipitation is 360-470 mm and higher. However there are years with precipitations higher than average and lower than average. Maximum precipitations fall in winter and early spring months. The coldest month is January with air temperature in the range of 0 to -29°C, the hottest month is July with average air temperature is +25.4°C, maximum of +41.1°C and more.

1065. The characteristic feather of the climate is strong wind activity and particularly 41% of winds have northern-eastern direction, while remaining 59% other directions. Weather climatic data at study period are presented in Table 187, Figure 141.

1066. Total amount of precipitation in fall 2008 was 177.4 mm, in winter -190.7 mm, spring 2009 -103.5 mm (March), 176.0 mm (April) or by 59.0 mm higher of the longterm, total amount for the period was 647.6 mm, i.e. it was more wet year in comparison with long-term (426.6 mm) or by 221.0 mm higher. Precipitations were observed at the first decade of June - 16.3 mm, or by 2.5 times higher over long-term.

1067. Relative humidity for the period from sowing up to booting stage was 71.7%, higher than long-term (57.5%), this tendency was continued up to milk ripeness. The air temperature, according to Akkavak station in fall was higher in comparison with long-term, winter was mild, number of unfrosted days was 138 days, which favored to winter wheat development. Since the farm prone to wind activity, the wind speed in some days reached 17 m sec-1, in many cases from 2 to 6-8 m sec-1 and higher. There were not winds only in 4 days out of 156 days. From April up to June wind activity continued and maximum wind speed was 11 m sec-1(April), 9 sec-1 (May and June). Akkawak station is located within farm in 1500 m far from the experimental site.

Table 187. Meteorological data for the period of 28 September 2008-31 March 2009

Moth	Relative Humidity,%	Air temperature, °C	Precipitations, mm	Maximum wind speed, m s ⁻¹
IX	61	20.5	14.5	8
long-term	48	19.9	5	
X	70	14	57.3	8
long-term	55	13.7	33.1	
XI	70	7.8	105.6	17
long-term	61	7.3	53	
XII	85	3.4	49.1	6
long-term	63	2.6	69	
I	74	3.2	36	8
long-term	58	0.2	59	
II	70	6.1	105.6	14
long-term	60	2.3	62.2	
III	65	10.9	103.5	
long-term	62	7.8	85.5	
IV	76	12.6	126.4	11
Long-term	60	14.7	72.0	
V	64	19.9	45.6	9
Long-term	54	20.0	40.2	
VI	44	22.5	9.1	9
Long-term	44	25.3	11.7	

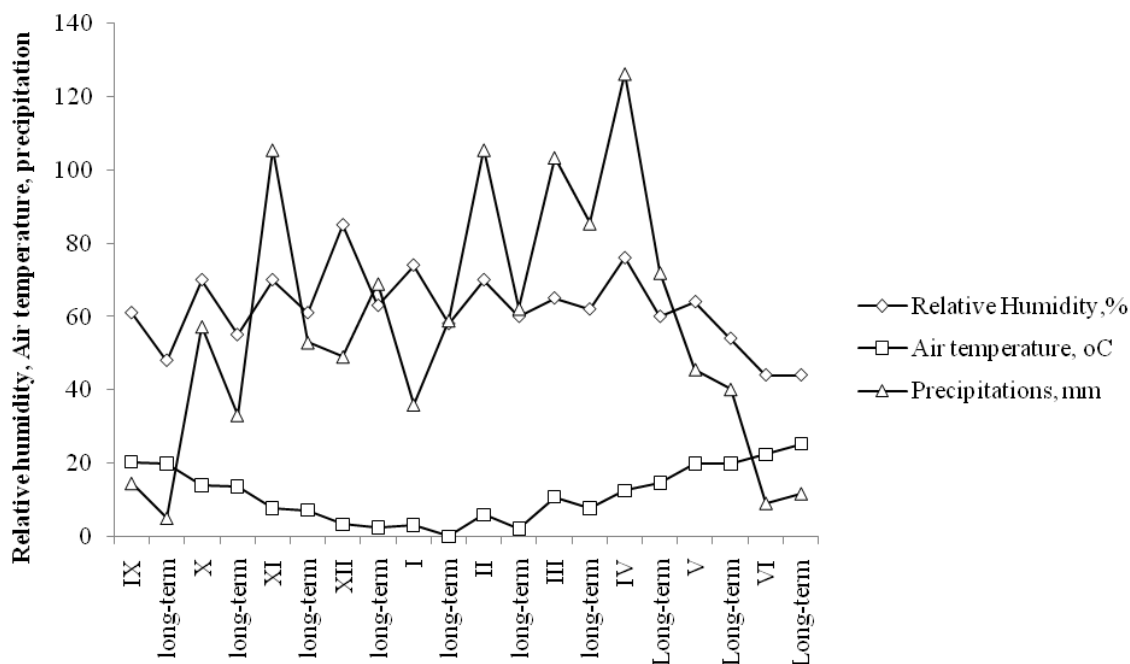


Figure 141. Meteorological parameters at the study period (2008-2009)

6.7.2.3 Methodology

1068. An experiment was established at non-saline sierozem soils at Uzbek Cotton research Institute’s experimental farm and neighbouring farms in Kibray district in Tashkent province in order to develop farm advisory for N management (Greenseeker instrument calibration) to find correlation between fertilisers’ application rates and plant biomass to get higher crop yields (Table 188).

Table 188. Treatments of the experiment

# Treatments	Nitrogen application rate, kg ha ⁻¹	Plant development stages when Nitrogen fertilizers were applied	Crop
1	N-50	F1-50% F3-50%	Winter wheat “Moskvichka” variety, 200 kg ha-1
2	N-100		
3	N-150		
4	N-200		
5	N-250		
6	N-0		

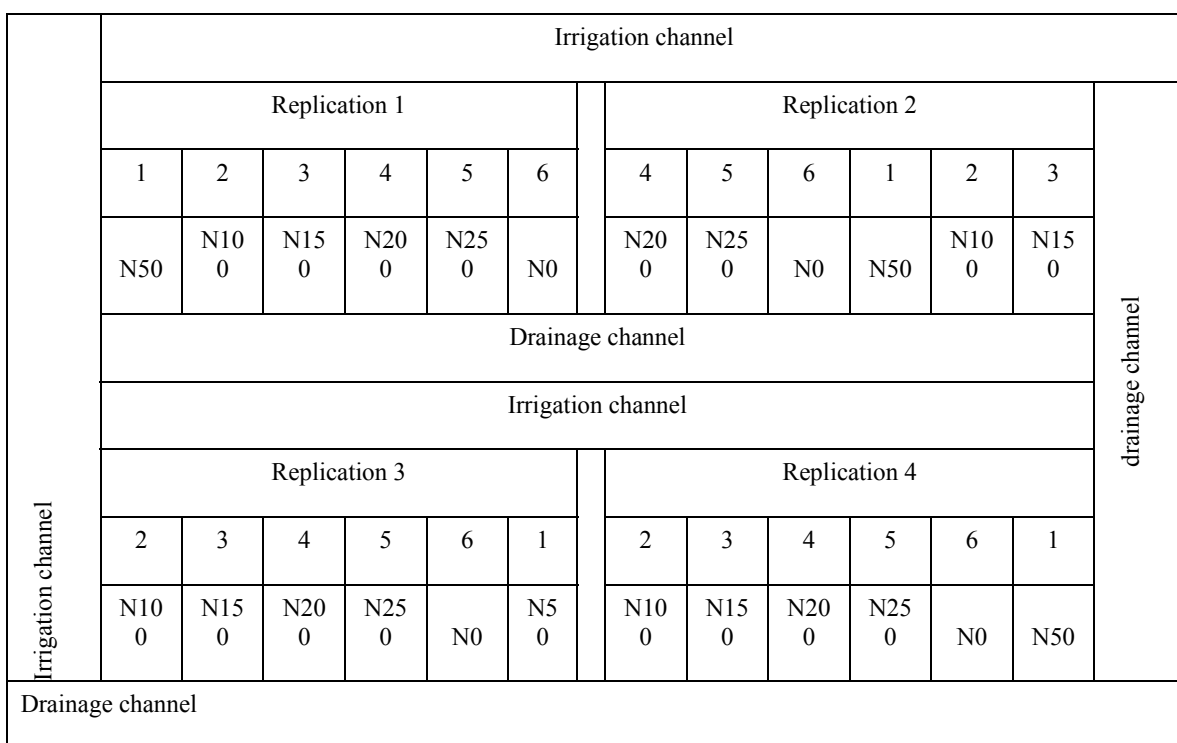


Figure 142. Layout of experimental treatments in field conditions

Table 189. Description of farmer plots with Nitrogen Rich Strips and traditional practices

№	Treatment	Crop, sowing technology
1	Nitrogen application at F1 stage -50%, and at F3 stage-50%	Winter wheat planted at standing cotton
2	Traditional farming practices	

1069. Total area under experiment is 720 m². Area of one subplot is 18 m². Length is 5 m and width is 3.6 m. The experimental layout was based on a randomized block design with 6 treatments and 4 replications in 2 tiers (Table 189, Figure 142).

1070. Phosphorous content at the soils of the experimental site is moderate, and potassium content is high. Organic matter content is 0.904% at plowed depth. Soil bulk density is 1.35 g cm⁻³ (Table 190).

Table 190. Initial content of nutritional elements in the soil before starting of the experiment

Soil depth, cm	Organic matter, %	Gross forms, %		Mobile forms, mg kg ⁻¹ soil		
		N	P	NO ₃	P	K
0-30	0.904	0.080	0.162	4.42	47.2	440
30-50	0.743	0.064	0.136	3.92	40.0	300

1071. Winter wheat “Moskvichka” superelita variety was sown at the sowing rate of 225 kg ha⁻¹. Experimental plot was established according to Uzbek Cotton RI’ methodology (1963, 1981, 2007). NDVI measurements were taken with Greenseeker instrument at weakly basis at four rows after winter wheat emergency until milk maturity stage.

1072. In order to determine nutrients in the soil before starting experiment soil samples were taken from 5 locations in envelope basis, in the under plowed (0-30 cm) and below under plowed soil horizon (30-60 cm). Soil analyses were undertaken at Uzbek Cotton RI Chemical lab under supervision of Dr. Tatyana Vais.

1073. In order to evaluate the Nitrogen removal from the soil, Nitrogen, Phosphorous and Potassium content in the soil and at the stems, kernels will be determined in each treatment and replication after crop harvesting.

1074. Crop yields have been determined from the whole subplot of each treatment and replication. Full description of wheat has been conducted just before harvesting. Plant density has been measured in each treatment. The same observations have been conducted at farmers’ plots.

1075. Farming practices at farmer plots were assigned in conformity with adopted farming practices and at research sites in according to work plan (Table 191, Table 192). Nitrogen fertilizers were applied at F1 and F3 stages of wheat development stages. The rates of Nitrogen for the farmers’ plots were estimated on the base of NDVI based Nitrogen calculator and these rates were applied for these farmer plots.

1076. According to work plan pre-experiment NPK elements at the soil depths were determined and the phosphorous and potassium fertilizers applied with taking into account basal nutrition content at the soil. Nitrogen fertilizers were applied at 2 equal splits at F1 and F3 winter wheat development stages.

Table 191. Farming practices conducted at the experimental plot (2008-2009).

№	Farming practices	1	2	3	4	5	6
1	Planting	24.09.08					
2	Superphosphate application	27.09.08	01.04.09				
3	Nitrogen fertilizer application on treatment F1-50% and F3-50%	26.09.08	11.02.09				
4	Irrigation	07.10.08					
5	NDVI measurements with Greenseeker	14.10.08 17.10.08 25.10.08	14.11.08 21.11.08 26.11.08	04.12.08 11.12.08 29.12.08	12.01.09 16.01.09 20.01.09 26.01.09	09.02.09 16.02.09 27.02.09	05.03.09 11.03.09 25.03.09 31.03.09
6	Herbicide "Biostar" application, 25 grams	12.03.09					
7	Weed control,	15.04.09	25.05.09				
8	Chemical spraying against yellow rust	21.05.09					
9	irrigation	09.10.08	07.03.09	04.06.09			
10	Harvesting	06.07.09					

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Table 192. Farming practices conducted at the farmer plots (2008-2009).

№	Farming practices	1	2	3	4	5	6
Map point #47 Farmer 1							
1	Planting	26.09.08					
2	Superphosphate application	27.09.08	01.04.09				
	Ureae	26.09.08	11.02.09				
3	Irrigation	27.09.08					
4	NDVI measurements with Greenseeker	25.10.08	14.11.08 21.11.08 26.11.08	04.12.08 11.12.08 29.12.08	12.01.09 16.01.09 20.01.09 26.01.09	09.02.09 16.02.09 27.02.09	05.03.09 11.03.09 25.03.09 31.03.09
Map point #86 Farmer 2							
1	Planting	15.10.08					
2	Superphosphate application	27.10.08	01.04.09				
	Ureae	27.10.08	17.02.09				
3	Irrigation	28.10.08					
4	NDVI measurements with Greenseeker	21.10.08 26.10.08	14.11.08 21.11.08 26.11.08	04.12.08 11.12.08 29.12.08	12.01.09 16.01.09 20.01.09 26.01.09	09.02.09 16.02.09 27.02.09	05.03.09 11.03.09 25.03.09 31.03.09
Map point #79 Farmer 3							
1	Planting	21.10.08					
2	Superphosphate application	27.10.08	01.04.09				
	Ureae	27.10.08	17.02.09				
3	Irrigation	28.10.08					
4	NDVI measurements with Greenseeker	21.10.08 26.10.08	14.11.08 21.11.08 26.11.08	04.12.08 11.12.08 29.12.08	12.01.09 16.01.09 20.01.09 26.01.09	09.02.09 16.02.09 27.02.09	05.03.09 11.03.09 25.03.09 31.03.09
Map point #80 Farmer 4							
1	Planting	16.10.08					
2	Superphosphate application	27.10.08	01.04.09				
	Ureae	27.10.08	17.02.09				
3	Irrigation	28.10.08					
4	NDVI measurements with Greenseeker	21.10.08 26.10.08	14.11.08 21.11.08 26.11.08	04.12.08 11.12.08 29.12.08	12.01.09 16.01.09 20.01.09 26.01.09	09.02.09 16.02.09 27.02.09	05.03.09 11.03.09 25.03.09 31.03.09

6.7.3 Results and discussions

1077. NDVI measurements started after 50% of full germination of winter wheat and first measurement was done on 14 October 2008, the NDVI curve during the winter wheat crop season is presented in Figure 144. As it seen in the Figures there were not much differences between treatments at initial stage, which was observed in farmer fields as well. Significant differences between plant biomass accumulations in dependence from nitrogen application rates were found after full germination, i.e. from 17 October 2008 (Figure 143. 6.3).

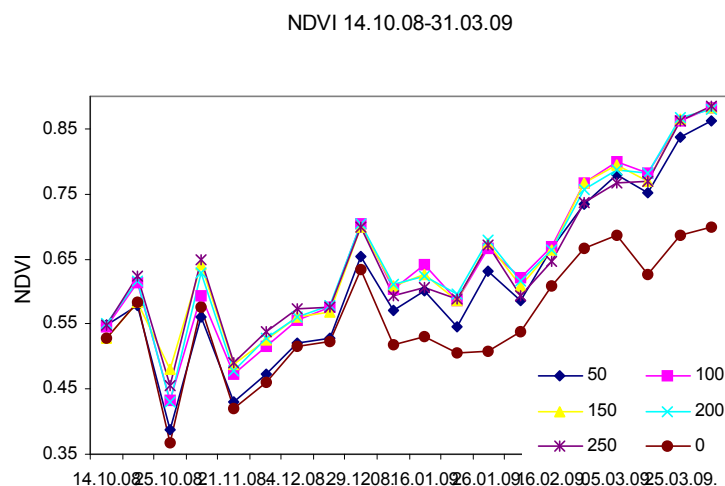


Figure 143. NDVI dynamics at experimental site with different N rate application (14.10.08-31.03.2009)

1078. Differences in NDVI values of Nitrogen rich strip and farmer practices at Farmer field 1 are observed from 21 November 2008 (Figure 144).

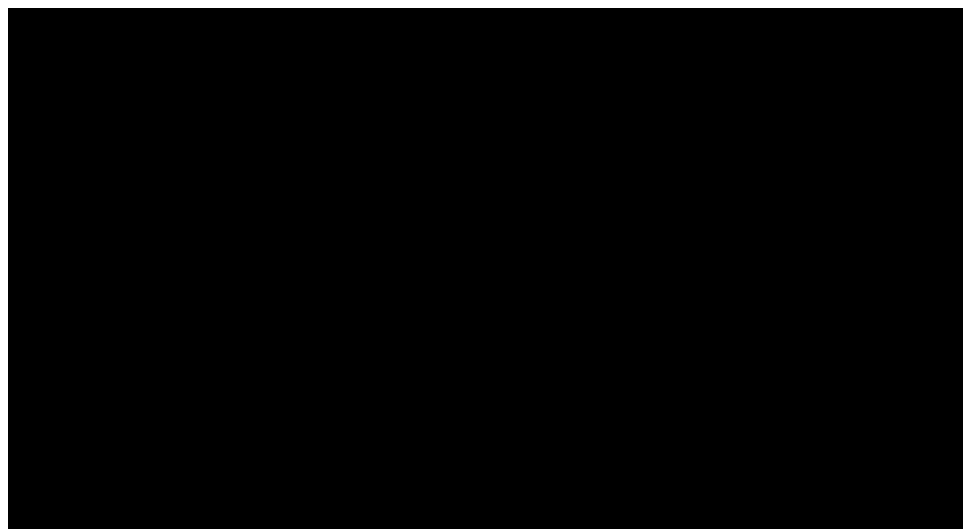


Figure 144. NDVI dynamics at Farmer field 1

1079. Higher NDVI at Nitrogen rich strips in comparison with that at farmer plots was observed from 26 November 2008 in farmer 2 (upper part), from 20 January 2009 in farmer 2 (middle part), and from 25 March 2009 in farmer 2 (down part). Before these periods, NDVI values in farmer fields with traditional practice of Nitrogen application were higher in comparison with that in experimental research sites (Figure 145, Figure 146, and Figure 147).

1080.



Figure 145. NDVI dynamics at Farmer field 2 (upper part)

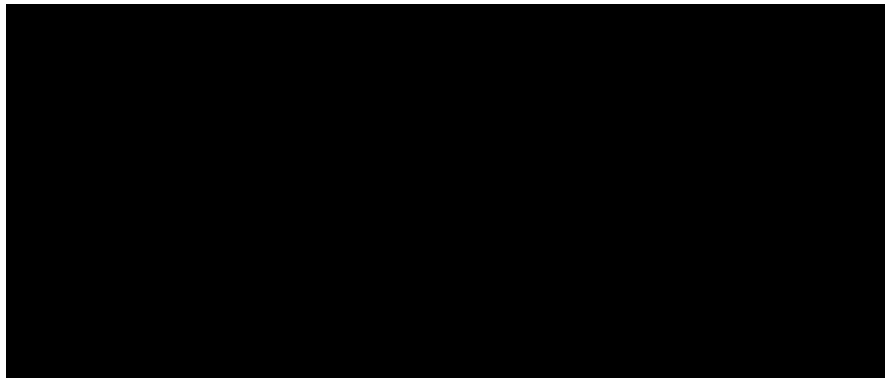


Figure 146. NDVI dynamics at Farmer field 2 (middle part)



Figure 147. NDVI dynamics at Farmer field 2 (bottom part)

1081. NDVI values at NRS at farmer plot#3 were significantly higher than at farmer practices, but those in 31 March at both sites were almost the same (Figure 148).

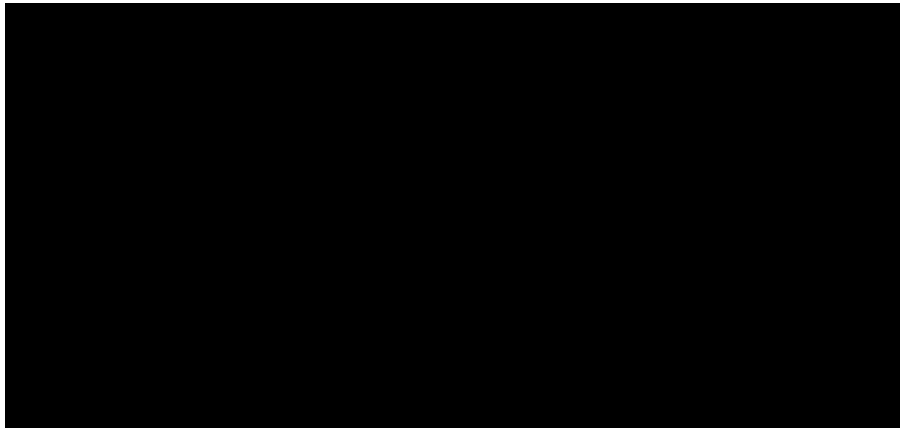


Figure 148. NDVI dynamics at Farmer field 3

1082. Maximum NDVI in farmer plot #4 was observed until 16 January 2009 and after there were not much differences in comparison with Nitrogen rich strip up to 31 March 2009, followed by higher NDVI values in experimental site with 2 splits Nitrogen application at F1 and F3 stage (Figure 149).



Figure 149. NDVI dynamics at Farmer field 4

1083. NDVI measurements from 1 April 2009 up to 23 May 2009 revealed reducing of NDVI in all treatments. This indicated □inalizing of biomass accumulation stage, which is visible in Figure 150. This tendency was also remained at farmer fields (Figure 151, Figure 152, Figure 153, Figure 154, Figure 155, and Figure 156).

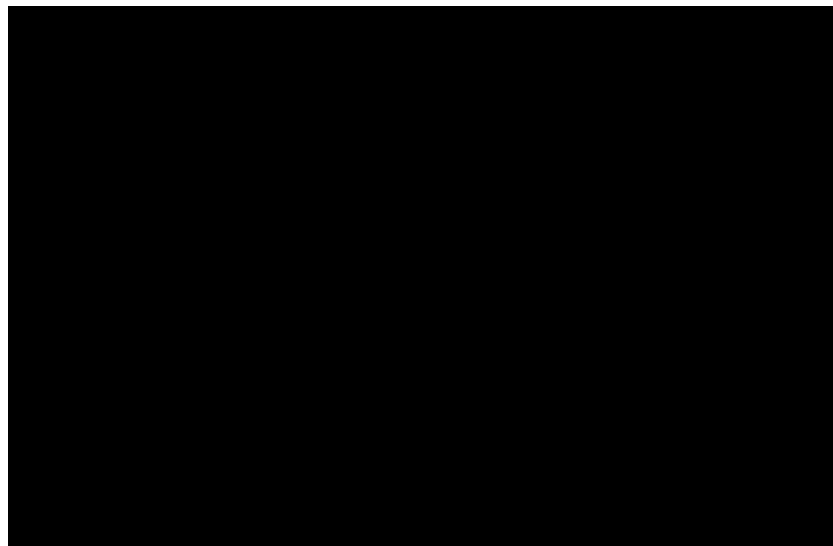


Figure 150. NDVI dynamics at experimental site with different N rate application (14.10.08-31.05.2009)



Figure 151. NDVI dynamics at Farmer field 1 (17.04-29.05.09)

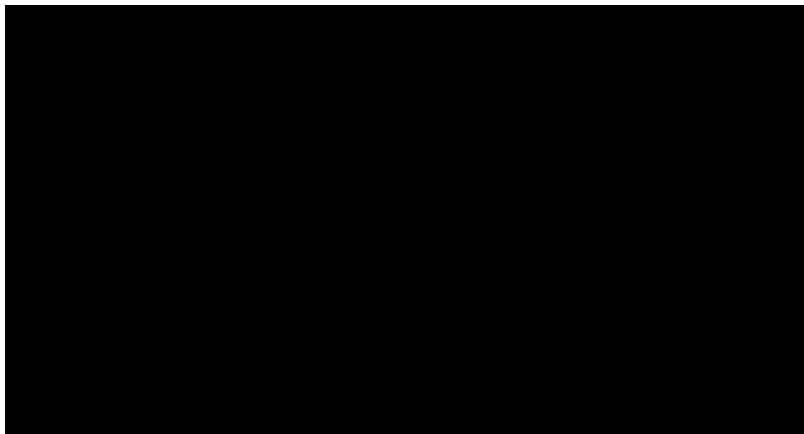


Figure 152. NDVI dynamics at Farmer field 2 (upper part) (17.04-29.05.09)

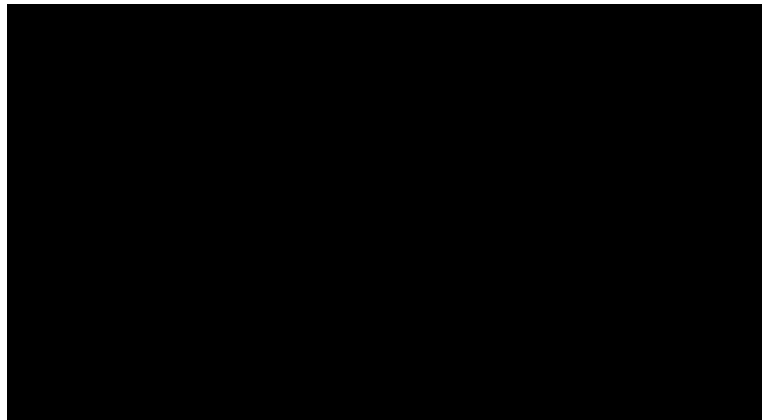


Figure 153. NDVI dynamics at Farmer field 2 (middle part) (17.04-29.05.09)

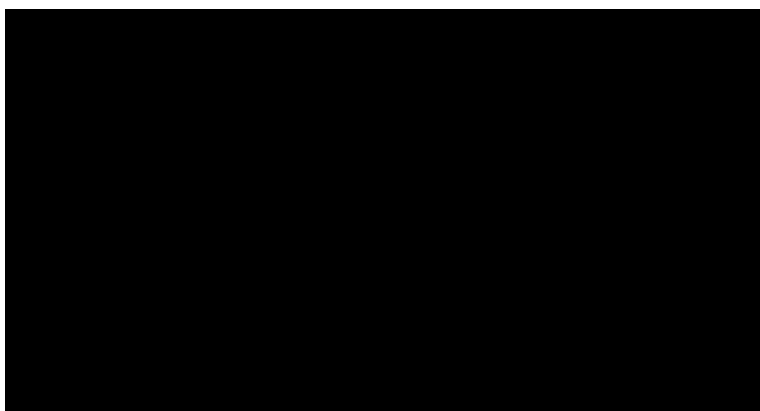


Figure 154. NDVI dynamics at Farmer field 2 (bottom part) (17.04-29.05.09)

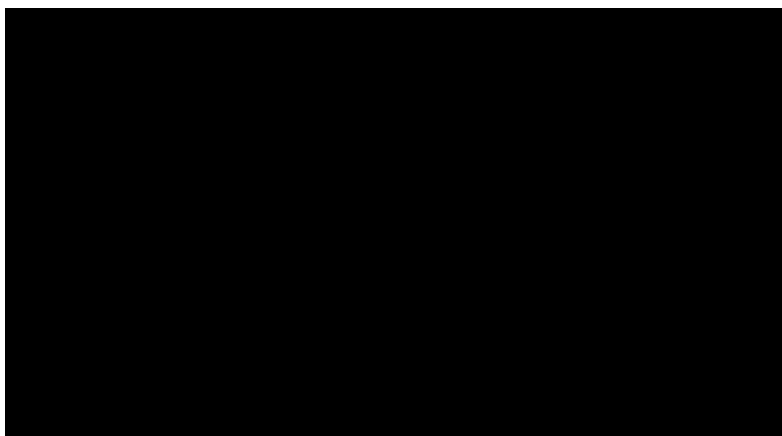


Figure 155. NDVI dynamics at Farmer field 3 (17.04-29.05.09)

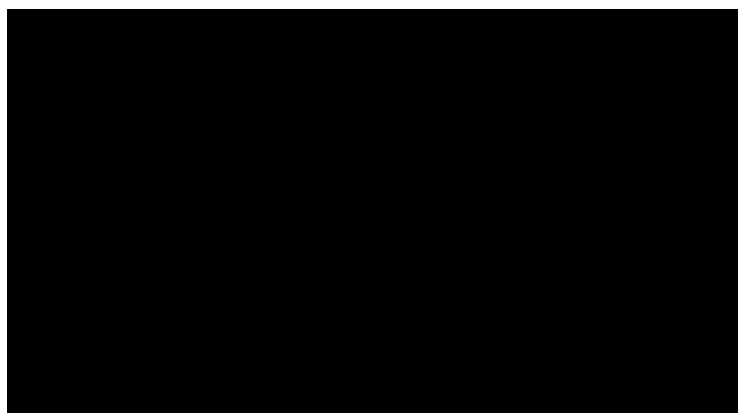


Figure 156. NDVI dynamics at Farmer field 4 (17.04-29.05.09)

1084. In farmer plot 2, additional Nitrogen was applied at the rows according to Nitrogen requirements to get potential crop yield. Crop yields of winter wheat obtained at different treatments are presented in Table 193.

1085. In all farmer plots, winter wheat yields were harvested on 5-7 July 2009. Crop productivity data will be presented later. Actual crop yields were determined for each farmer plot. Plant density and grain yield data for four farmer plots are presented in Table 194 and Table 195 and that for Nitrogen response treatments in Table 196, Table 197 and Table 198, respectively.

Table 193. Effect of N rate to plant height, grain yields and other crop attributes at Uzbek Cotton RI site

N ₂ Treatments	Plant height, cm	Spike length, cm	Number of grains in 1 spike	Weight of grains in 1 spike	Weight of 1000 seeds, g	Number of stems, million Pieces	Grain yield, t ha ⁻¹
1	87.8	8.0	40.7	1.6	38.4	2.082	3.3
2	83.0	7.7	38.1	1.4	37.2	2.133	3.1
3	85.1	7.9	41.0	1.6	38.2	2.332	3.7
4	86.3	7.9	40.4	1.5	38.0	2.471	3.8
5	85.9	7.6	37.8	1.4	37.5	2.524	3.5
6	84.7	8.0	42.4	1.7	39.4	1.285	2.1

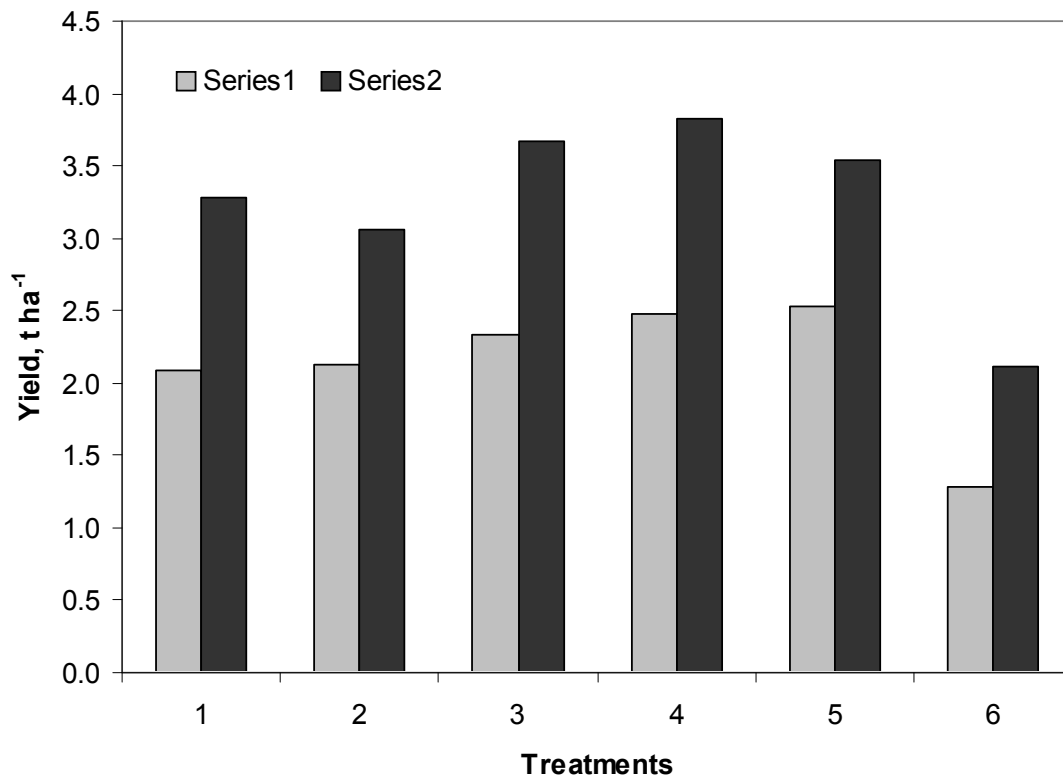


Figure 157. Effect different treatments on plant density and winter wheat yields

Table 194. Total weight of grain +straw at different rows of farmer plots (NRS-nitrogen rich strips, FP-farmer practices), kg/plot

Farmers plots	rows								Total
	1	2	3	4	5	6	7	8	
Farmer 1									
NRS	6.3	7.1	5.8	6.7	6.4	5.1	5.0	6.4	48.8
FP*	4.4	5.7	6.0	5.6					21.7
FP	5.0	5.1	4.2	4.0					18.3
Farmer 2 (upper part)									
NRS	5.5	7.0	5.0	6.0	4.5	6.0	6.3	5.2	45.5
FP*	7.8	6.0	4.6	4.1					22.5
FP	5.5	5.3	6.0	5.6					22.4
Farmer 2 (middle part)									
NRS	6.0	5.2	4.8	4.2	5.8	7.4	6.5	5.5	45.4
FP*	7.3	6.2	6.4	5.9					25.8
FP	5.8	7.0	6.3	7.5					26.6
Farmer 2 (bottom part)									
NRS	7.8	8.1	8.0	8.5	9.5	10.0	9.7	8.9	70.5
FP*	8.0	7.5	7.0	6.7					29.2
FP	6.9	7.4	7.7	8.0					30.0
Farmer 3									
NRS	4.7	5.7	5.3	4.9	5.3	5.6	4.5	4.8	40.8
FP*	4.9	4.7	4.9	5.3					19.8
FP	4.0	4.1	3.9	4.9					16.8
Farmer 4									
NRS	4.9	5.6	5.3	5.7	5.1	4.7	5.8	4.7	41.8
FP*	5.4	5.6	4.7	4.9					20.6
FP	4.8	4.2	4.9	5.1					19.0

FP*-Farmer plots where N was applied at F5 stage using Nitrogen algorithm (on the base of Yield-INSEY function)

**Table 195. Plant density at different rows of farmer plots (NRS-nitrogen rich strips, FP-farmer practices),
Number of plants/m²**

Farmers plots	Rows								Average
	1	2	3	4	5	6	7	8	
Farmer 1									
NRS	362.24	275.51	346.94	309.37	271.94	283.67	428.57	291.84	321.26
FP*	200.37	242.35	244.16	221.94					227.20
FP	219.76	181.54	217.37	198.00					204.17
Farmer 2 (upper part)									
NRS	329.64	273.27	358.30	354.55	303.01	294.29	342.49	277.55	316.64
FP*	346.36	257.98	341.58	464.84					352.69
FP	267.53	259.26	343.00	348.14					304.48
Farmer 2 (middle part)									
NRS	359.69	327.27	355.84	357.14	437.76	287.76	427.23	398.43	368.89
FP*	334.42	409.90	332.03	368.18					361.13
FP	284.73	336.80	292.21	335.25					312.25
Farmer 2 (bottom part)									
NRS	383.49	396.57	448.00	387.01	439.98	382.50	413.40	398.40	406.17
FP*	387.40	367.20	377.00	372.00					375.90
FP	305.75	364.29	309.74	374.90					338.67
Farmer 3									
NRS	364.80	361.78	458.15	346.36	357.14	312.92	355.66	394.56	368.92
FP*	224.49	269.92	263.78	262.76					255.24
FP	253.90	239.61	253.06	257.98					251.14
Farmer 4									
NRS	356.20	394.80	307.50	353.70	304.80	347.50	303.60	309.60	334.71
FP*	301.30	301.40	300.00	285.60					297.08
FP	231.22	320.78	259.89	283.86					273.94

FP-Farmer plots where N was applied at F5 stage using Nitrogen algorithm (on the base of Yield-INSEY function)*

Table 196. Grain yield at different rows of farmer plots (NRS-nitrogen rich strips, FP-farmer practices), t ha-1

Farmers plots	Rows								Average
	1	2	3	4	5	6	7	8	
Farmer 1									
NRS	5.80	4.35	5.07	5.88	4.38	4.94	9.34	6.07	5.73
FP*	3.87	3.95	3.25	3.22					3.57
FP	3.14	3.00	2.89	3.78					3.20
Farmer 2 (upper part)									
NRS	5.50	4.34	6.02	5.99	3.67	3.59	5.48	4.66	4.91
FP*	4.68	4.13	5.81	7.44					5.51
FP	4.28	4.41	6.52	4.87					5.02
Farmer 2 (middle part)									
NRS	5.04	5.56	4.63	4.64	7.00	5.76	5.13	4.78	5.32
FP*	5.02	6.56	4.65	6.63					5.71
FP	3.70	4.38	4.97	5.36					4.60
Farmer 2 (bottom part)									
NRS									
FP*	5.85	5.25	6.18	5.36					5.66
FP									
Farmer 3									
NRS	5.73	6.26	6.46	5.51	5.96	5.10	6.51	5.92	5.93
FP*	3.03	3.97	2.53	2.92					3.11
FP	3.10	2.40	4.38	3.22					3.28
Farmer 4									
NRS	5.70	7.82	6.06	3.86	3.96	4.69	4.37	3.84	5.04
FP*	3.43	5.36	3.99	5.28					4.52
FP	2.40	5.16	4.68	3.29					3.88

FP*-Farmer plots where N was applied at F5 stage using Nitrogen algorithm (on the base of Yield-INSEY function)

Table 197. Plant density at different N rate application treatments, Number of plants/m²

№ Treatments	replication	rows						Average
		1	2	3	4	5	6	
1	1	337	309	310	356	310	272	315
2	1	305	337	369	346	269	379	334
3	1	398	397	271	343	301	367	346
4	1	352	413	367	431	333	312	368
5	1	324	508	438	334	325	421	392
6	1	216	195	199	0	79	165	142
1	2	307	377	271	342	336	229	310
2	2	282	326	413	355	263	315	326
3	2	365	445	379	500	400	303	399
4	2	393	397	413	470	328	368	395
5	2	367	470	415	317	390	386	391
6	2	174	160	231	168	270	213	203
1	3	345	357	289	343	370	264	328
2	3	284	330	396	196	272	349	304
3	3	350	341	296	270	323	586	361
4	3	274	344	462	418	345	409	375
5	3	363	379	341	277	320	397	346
6	3	266	274	335	359	303	350	314
1	4	292	337	337	407	270	317	327
2	4	270	288	338	361	295	382	322
3	4	360	366	343	351	337	327	347
4	4	384	406	313	278	342	328	342
5	4	438	293	311	284	333	272	322
6	4	412	327	367	285	304	343	340

Table 198. Grain yield at different N rate application treatments, t ha-1

Treatments	replication	rows						Average
		1	2	3	4	5	6	
1	1	5.66	5.17	5.76	3.92	5.43	4.65	5.10
2	1	5.10	6.63	4.93	6.37	6.21	5.79	5.84
3	1	5.38	4.72	5.11	5.73	6.82	6.20	5.66
4	1	5.63	7.41	4.20	6.73	4.74	3.58	5.38
5	1	6.06	7.84	4.38	3.28	7.07	4.04	5.45
6	1	4.16	4.10	1.43	0.00	3.31	2.55	2.59
1	2	4.67	3.93	4.36	3.42	2.29	3.51	3.70
2	2	2.84	5.78	3.07	3.55	3.15	3.85	3.71
3	2	5.88	4.36	5.56	5.00	3.03	4.69	4.75
4	2	6.09	5.33	5.15	4.70	3.68	6.55	5.25
5	2	5.54	5.94	5.15	3.17	3.86	6.45	5.02
6	2	3.05	4.76	3.60	1.68	2.13	2.94	3.03
1	3	4.42	4.40	3.75	5.03	5.84	3.17	4.44
2	3	4.46	4.36	5.54	2.51	4.92	5.34	4.52
3	3	3.46	5.45	3.31	3.24	4.40	9.67	4.92
4	3	4.16	5.16	6.97	6.90	6.98	6.38	6.09
5	3	6.17	7.32	6.16	5.70	3.36	5.00	5.62
6	3	3.17	5.64	5.66	4.52	6.84	4.72	5.09
1	4	2.95	4.22	5.25	5.82	2.21	4.69	4.19
2	4	4.39	2.94	6.25	4.54	2.80	5.00	4.32
3	4	6.69	6.47	4.57	5.79	3.94	4.48	5.32
4	4	5.84	6.09	4.73	3.84	6.90	5.11	5.42
5	4	7.44	5.65	5.63	5.84	3.50	3.42	5.25
6	4	7.54	5.16	4.96	5.42	4.59	4.67	5.39

6.8 Uzbekistan: Activity 6. Evaluate the impact of laser-assisted precision land leveling on salinity, water savings and crop performance with use of EM 38 instrument and an optical crop canopy sensor

1086. The hydraulic (drug type) scrapper bucket and laser system have been received from ICARDA in August, 2008. Because of breakage of tractors and lack of petroleum farmers could not implement the soil tillage in time. This results on the process of finding volunteers to make land leveling by laser technology. Therefore, these activities were carried out in Pahtakor district of Jizzakh province and in Sardoba district of Syr-Darya province.

6.8.1 Materials and methods

1087. Land leveling activities were implemented with laser equipment “Rugby 100LR”, a small-sized scraper bucket with width of 3 m (Figure 158). For work with tilled tractors in small farms and tractor TTZ-80.10. Topogeodetic survey was conducted by laser system that has considerably simplified geodetic works. After carrying out of a land leveling, the test topogeodetic survey was carried out.

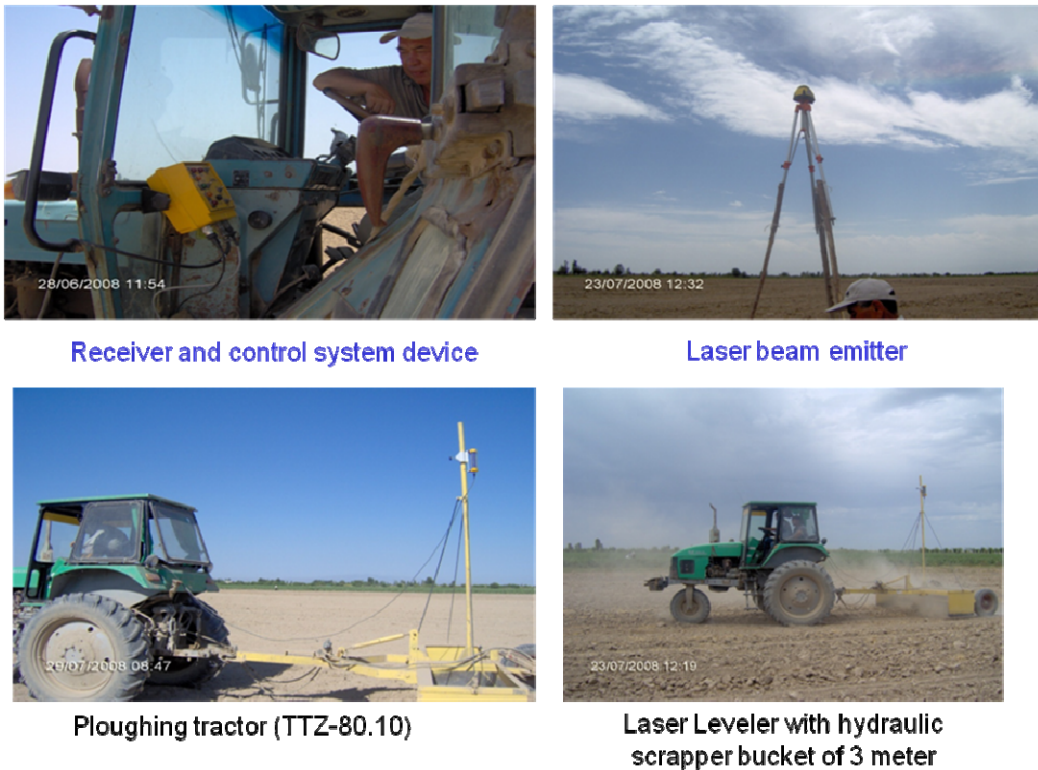


Figure 158. Carrying out of precisely laser assisted land leveling

6.8.2 Results

1088. From August 2008 up to July 2009 laser assisted land leveling was implemented at the following farmers' fields:

- Sherzod Samandar Birligi farm in Syrdarya province – 7 ha
- Esanboy ota farm in Pakhtakor district of Jizzakh province – 5 ha
- Branch of Uzbek Cotton Research Institute site in the Jizzakh province -6 ha
- Chavandoz – AUT farm in Pakhtakor district of Jizzakh province – 4.5 ha
- Uktam farm in Pakhtakor district of Jizzakh province – 5 ha

TOTAL: 27.5 hectares

1089. After harvesting of winter wheat, soil tillage and harrowing was conducted. Geodetic survey was done in every plot with area of 20x20 m using laser system. To minimize cutting of high fertile soil layer, the whole plot was divided to small plots with 2-3 ha in reference to irrigation channels. Project designn was implemented for the area in the computer (Figure 159). Land surface profiles before and after land leveling with laser assisted system are presented in Figure 160 and Figure 161, respectively.

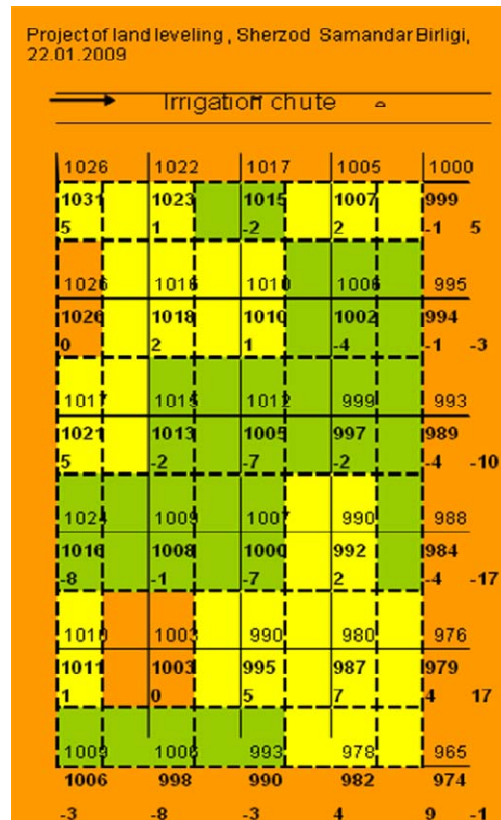


Figure 159. Land leveling map in Sherzod Samandar Birligi

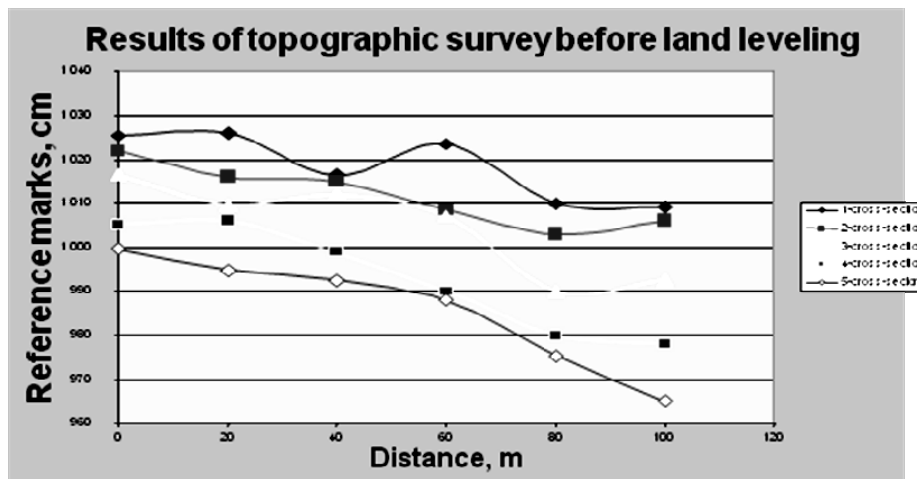


Figure 160. Results of topogeodetic survey before land leveling

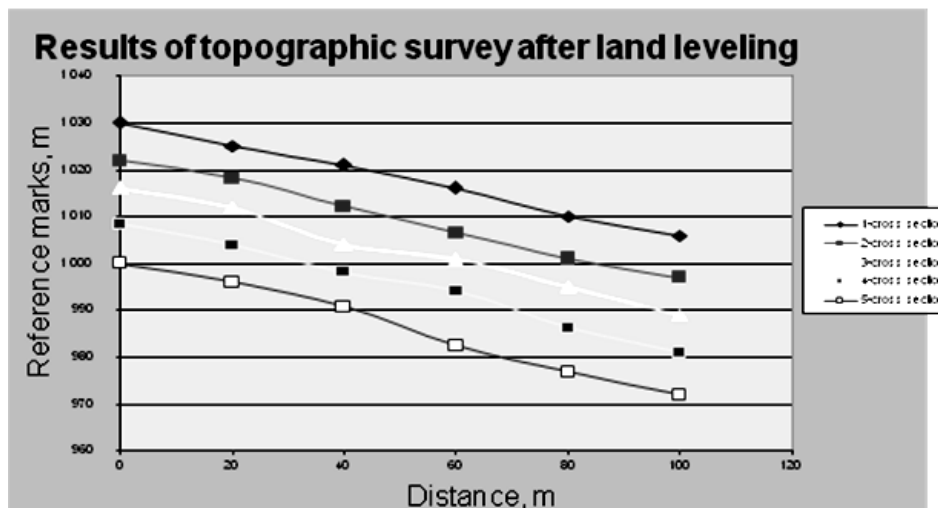


Figure 161. Results of topogeodetic survey after land leveling

1090. Test topogeodetic survey followed by precisely land leveling has revealed that land leveling was implemented at high quality (undulations were $\pm 1-2$ cm) (Figure 3.7.4). Total cost incurred in laser assisted system at experimental site was assessed as 118200 UZS (Table 199).

In 2008 winter wheat was sown by the Indian raised bed planter (model: Dasmesh) on both experimental sites leveled by laser system. Farming practices are presented in Table 202, Table 204. Data on winter wheat irrigation regimes, plant growth, development and grain yields at the leveled and control sites are presented in Table 200,

1091. Table 203, and Table 201.

1092. Soil profile salinity (EC) varied across the raised beds and demonstrated an increase in the soil salinity on top of raised beds, which did not affect winter wheat yields (Table 205).

Table 199. Costs incurred in laser leveling in Esanboy ota farm in Pakhtakor district of Jizzakh province

№	Farming practices	Machinery	Petrol discharge, L ha-1	Cost of petrol, UZS	Salary of tractor driver, UZS ha-1	Total, UZS
1	Tillage	BT-150	40	41600	15000	56600
2	Harrowing	TTZ-80.11	10	10400	5000	15400
3	Land leveling	TTZ-80.11	30	31200	15000	46200
	Total					118200

Table 200. Winter wheat irrigation regime for 2008-2009 on leveled (5 ha) and control (5 ha) fields at Uzbek Cotton Research Institute site, Pakhtakor district, Jizzakh province

№ irrigation	Leveled site		Control	
	Irrigation date	m ³ ha-1	Irrigation date	m ³ ha-1
1 st irrigation	28 October 2008	1150	28 October 2008	1600
2 nd irrigation	26 February 2009	900	26 February 2009	1300
3 rd irrigation	15 March 2009	840	15 March 2009	1000
4 th irrigation	20 May 2009	750	20 May 2009	1000
Irrigation rate	3640		4900	

Table 201. Winter wheat irrigation regime for 2008-2009 at leveled (2 ha) and control plot (2 ha) at Sherzod Samandar Birligi farm in Sardoba district of Syrdarya province

№ irrigation	Leveled		Control	
	Irrigation date	m ³ ha-1	Irrigation date	m ³ ha-1
First irrigation	18 October 2008	1100	18 October 2008	1700
Second irrigation	18 February 2009	920	18 February 2009	1450
Third irrigation	5 March 2009	900	5 March 2009	1300
Fourth irrigation	7 April 2009	870	7 April 2009	1200
Irrigation rate	3790		5650	

Table 202. Farming practices applied for winter wheat crop (2008-2009) on leveled (5 ha) and control (5 ha) plots of Uzbek Cotton RI site in Pakhtakor district, Jizzakh province.

№	Farming practices		Dates
	Leveled site	Control	
1	Land leveling	Soil tillage	7 July 2008
2	Harrowing	Harrowing	9 July 2008
	Land leveling		27-29 July 2008
3	Fertilizers application: Ammonium phosphate, 150 kg ha-1	Fertilizers application: Ammonium phosphate, 150 kg ha-1	25 October 2008
4	Sowing of winter wheat “Polovchanka” variety at a seed rate of 230 kg ha-1	Sowing of winter wheat “Polovchanka” variety at a seed rate of 200 kg ha-1	25 October 2008
5	Winter wheat irrigation. 1 st irrigation. Irrigation rate – 1150 m ³ ha-1	Winter wheat irrigation. 1 st irrigation. Irrigation rate – 1600 m ³ ha-1	25 October 2008
6	Fertilization: Ammonium Nitrate – 100 kg ha-1	Fertilization: Ammonium Nitrate – 100 kg ha-1	8 February 2009
7	2 nd irrigation of winter wheat. Irrigation rate- 900 m ³ ha-1	2 nd irrigation of winter wheat. Irrigation rate- 1300 m ³ ha-1	26 February 2009
	Fertilization: Ammonium Nitrate – 150 kg ha-1	Fertilization: Ammonium Nitrate – 150 kg ha-1	3 March 2009
	Suspension (Ureae 10 kg ha-1, Ammonium phosphate 16 kg ha-1, Potassium 10 kg ha-1)	Suspension (Ureae 10 kg ha-1, Ammonium phosphate 16 kg ha-1, Potassium 10 kg ha-1)	9 March 2009
	3 rd irrigation of winter wheat. Irrigation rate – 840 m ³ ha-1.	3 rd irrigation of winter wheat. Irrigation rate – 1000 m ³ ha-1.	15 March 2009
8	Herbicide application «Grandstar» 20 g ha-1	Herbicide application «Grandstar» 20 g ha-1	30 March 2009
	Fertilization: Ammonium Nitrate – 200 kg ha-1	Fertilization: Ammonium Nitrate – 200 kg ha-1	8 April 2009
10	Suspension (Ureae 10 kg ha-1, Ammonium phosphate 16 kg ha-1, Potassium 10 kg ha-1)	Suspension (Ureae 10 kg ha-1, Ammonium phosphate 16 kg ha-1, Potassium 10 kg ha-1)	20 April 2009
12	4 th irrigation of winter wheat. Irrigation rate – 750 m ³ ha-1	4 th irrigation of winter wheat. Irrigation rate – 1000 m ³ ha-1	9 May 2009
13	Biological yield -4.46 t ha-1.	Biological yield – 4.04 t ha-1.	
	Actual yield – 2.95 t ha-1.	Actual yield – 2.60 t ha-1.	6 June 2009

Table 203. Effect of laser leveling on growth and development of winter wheat on leveled (5 ha) and control (5 ha) experimental sites in “UCRI” of Pakhtakor district in the Jizzakh province 2008-2009.

Treatments	Plant height, cm			Number of spikes in 1m ²	Number of grain in 1 spike, pieces.	Weight of 1 spike, g	Biological yield, t ha-1
	1 April 2009	1 May 2009	1 June 2009				
Control plot	42.5	69.3	89.2	382	31.6	1.06	4.04
Leveled site	46.7	71.2	92.7	354	36.8	1.26	4.46

Table 204. Farming practices applied for winter wheat crop (2008-2009) on leveled (2 ha) and control (2 ha) plots of Sherzod Samandar Birligi farm in Sardoba district, Syrdarya province

№	Farming practices		Dates
	Leveled	Control plot	
1	Leveled	Control plot	
2	Soil tillage	Soil tillage	4 August 2008
3	Harrowing	Harrowing	7 August 2008
4	Land leveling		14 September 2008
5	Fertilization: Ammonium phosphate, 150 kg ha-1	Fertilization: Ammonium phosphate, 150 kg ha-1	10 October 2008
6	Winter wheat “Tanya” variety, sowing rate-150 kg ha-1	Winter wheat “Tanya” variety, sowing rate -240 kg ha-1	14-16 October 2008
7	Winter wheat irrigation. 1 st irrigation. Irrigation rate – 1100 m ³ ha-1	Winter wheat irrigation. 1 st irrigation. Irrigation rate – 1700 m ³ ha-1	18 October 2008
8	Fertilization: Ammonium Nitrate – 100 kg ha-1	Fertilization: Ammonium Nitrate – 100 kg ha-1	15 February 2009
9	2 nd irrigation of winter wheat. Irrigation rate- 920 m ³ ha-1	2 nd irrigation of winter wheat. Irrigation rate- 1450 m ³ ha-1	18 February 2009
10	Fertilization: Ammonium Nitrate – 200 kg ha-1	Fertilization: Ammonium Nitrate – 200 kg ha-1	28 February 2009
11	Suspension (Ureae 10 kg ha-1, Ammonium phosphate 16 kg ha-1, Potassium 10 kg ha-1)	Suspension (Ureae 10 kg ha-1, Ammonium phosphate 16 kg ha-1, Potassium 10 kg ha-1)	2 March 2009
12	3 rd irrigation of winter wheat. Irrigation rate - 900 m ³ ha-1	3 rd irrigation of winter wheat. Irrigation rate - 1300 m ³ ha-1	5 March 2009
13	Herbicide application “Grandstar” -20 g ha-1	Herbicide application “Grandstar” -20 g ha-1	9 March 2009
14	Spraying of fungicide “Alto super” -330 g ha-1	Spraying of fungicide “Alto super” -330 g ha-1	1-2 April 2009
15	Fertilization: Ammonium Nitrate - 200 kg ha-1	Fertilization: Ammonium Nitrate - 200 kg ha-1	5 April 2009
16	4 th irrigation of winter wheat. Irrigation rate - 870 m ³ ha-1	4 th irrigation of winter wheat. Irrigation rate - 1200 m ³ ha-1	7 April 2009
17	Biological yield -3.34 t ha-1.	Biological yield -2.89 t ha-1.	
18	Actual yield – 3.80 t ha-1.	Actual yield – 2.70 t ha-1.	6 June 2009

Table 205. Electro conductivity measurements (dS m⁻¹) under winter wheat on leveled plots in Sherzod-Samandar birligi farm (15.05.2009)

Soil depth, cm	Instrument readings	Soil temperature, °C	EC corrected on the base of soil temperature, dS m ⁻¹	Soil salinity, ECe, dS m ⁻¹	Soil salinity degree
On top of raised beds					
0-10 cm	0.4	24	0.41	1.63	Non saline
10-20 cm	0.64	23.3	0.67	2.66	Slight saline
20-30 cm	0.77	20	0.85	3.39	Slight saline
30-40 cm	0.96	17.9	1.09	4.38	Moderate saline
40-50 cm	1.08	17	1.25	5.01	Moderate saline
50-60 cm	1.16	16.6	1.35	5.38	Moderate saline
60-70 cm	1.28	16.1	1.51	6.04	Moderate saline
70-80 cm	1.33	15.8	1.57	6.28	Moderate saline
80-90 cm	1.22	15.7	1.44	5.76	Moderate saline
90-100 cm	1.09	15.6	1.29	5.14	Moderate saline
Mean				4.57	Moderate saline
On the slope					
0-10 cm	0.36	23.4	0.37	1.50	Non saline
10-20 cm	0.55	20.1	0.61	2.42	Slight saline
20-30 cm	0.64	18.8	0.72	2.87	Slight saline
30-40 cm	0.69	18.1	0.79	3.15	Slight saline
40-50 cm	0.72	18	0.82	3.28	Slight saline
50-60 cm	0.78	17.5	0.90	3.62	Slight saline
60-70 cm	0.7	17	0.81	3.25	Slight saline
70-80 cm	0.75	16.5	0.87	3.48	Slight saline
80-90 cm	1.02	16.1	1.20	4.81	Moderate saline
90-100 cm	0.94	16.1	1.11	4.44	Moderate saline
Mean				3.28	Moderate saline
On the bottom of furrow					
0-10 cm	0.33	18.9	0.37	1.48	Non saline
10-20 cm	0.35	18.4	0.40	1.60	Non saline
20-30 cm	0.36	18	0.41	1.64	Non saline
30-40 cm	0.38	17.5	0.43	1.73	Non saline
40-50 cm	0.68	16.7	0.79	3.16	Slight saline
50-60 cm	0.82	16.3	0.97	3.87	Slight saline
60-70 cm	0.68	16.1	0.80	3.21	Slight saline
70-80 cm	0.7	15.7	0.83	3.30	Slight saline
80-90 cm	0.88	15.8	1.04	4.15	Moderate saline
90-100 cm	0.97	15.7	1.14	4.58	Moderate saline
Mean				2.87	Moderate saline

6.8.3 Discussion

1093. Experiment was successful because there was opportunity to organize the precision laser leveling quite quickly by not taking lands out of agricultural production. The reasons of the success consist in small size of the scheduler, an opportunity to use a tilled tractor and effective solution for the organizational issues.

1094. Earlier, capital land leveling was performed in many hectares of irrigated lands, but now there is need to conduct the land leveling by not taking lands out of agricultural production. Complex including the small size leveler, laser equipment “Rugby 100LR”, and tilled tractor could successfully solve the issue.

1095. There are several issues to solve this problem: low technological level of many farmers’ a tractors; petroleum products and financial assets issues; and many other organizational issues, which are solved out of time.

1096. The proposed laser assisted land leveling technology, consisting of the small-size schedulers with width of a scraper bucket of 3 meters, a tilled tractor and laser systems, successfully solve the specified above issues and provides high accuracy of land leveling in comparison with traditional methods of land leveling which is based on long-wheelbase and large-size schedulers and using of tractor powers by not applying the laser system. Operational land leveling by using the laser-assisted method has never been tested before.

1097. The offered technology in general consists in the following steps: geodetic survey has to be implemented in every plot of all intended area at the size of 20x20 m. Depending on slope of the land, with a view of minimization of cutting of high fertile soil layer, the whole plot should be divided into small plots with area of 1-3 ha. Land leveling design, in the reference to irrigation channels and irrigation direction, has to be composed in the computer. The laser system beam has to be established on the designed bias according to the land leveling design, and land leveling works has to be done in automatic regime.

6.8.4 Conclusions

1098. From August 2008 up to July 2009 laser assisted land leveling was implemented under SLMR project on 27.5 ha area

1099. The operational experience for 10 month has shown that farmers by themselves are capable to implement the laser land leveling using ready land leveling design after taking one week training.

1100. It would be possible to out scale the technology on greater areas, however absence of the free lands for the given period has not allowed making it.

1101. Research has allowed establishing the efficiency of the technology:

- Labor productivity at carrying out of precisely laser assisted land leveling was found to be 2 hectares per hectare;
- Cost of 1 hectares of land leveling (including a ploughing, harrowing) makes up 118200 UZS;
- The land leveling productivity was in the range of 150-300 m³ ha⁻¹;
- Accuracy of a land leveling make up \pm 2-3 cm
- Uniform soil moisture distribution at the minimal water losses during irrigations;
- Water savings at each irrigation ranged from 500 to 600 m³ ha⁻¹;
- After land leveling productivity of wheat enhanced from 13.5 % up to 40.7 %;
- Growth of labor productivity of irrigators was 2.5 times.

6.9 Uzbekistan: Activity 7. Dissemination of results and development of mechanisms for up scaling and scaling out the SLMR options

1102. During two-year research the Farmer Field Days were conducted at each experimental site. More than 65 participants attended the Farmer day, which was organized in the Jizzakh site on 29 July 2007. Through this event information related with laser land leveling, new multi-crop raised bed planter, intercropped sowing of maize, cotton and mung bean were shared with farmers in Syrdarya province, Uzbekistan. Two posters were presented; information booklets and brochures related to introducing of new technologies were disseminated among farmers. The participants involved in the event were farmers, representatives from water use Associations, Ministry of Agriculture and Water resources of Uzbekistan, local authority, mass media, CACILM secretariat. Field day was covered by newspaper “Pravda Vostoka” where was published full-size article on research results.

1103. Farmer Field Day was conducted in Kyzylkum site of Kenimeh district of Navoi province of Uzbekistan on 2nd September 2008. The participants involved in the seminar were ICARDA specialists guided by Dr. Raj Gupta, Project Manager, Prof. Rabimov, Director of Uzbekistan Republican Center of agriculture electrification, Dr. K. Toderich, ICBA representative, Mr. M. Narzиеv, vice-president of “Uzbek karakul” Association, Dr. A. Ashurov, president of Navoi Association “Karakul”, “Shirkat” and Farmers Associations, main specialists, farmers, scientists from NARS institutions such as Samarkand Research Institute of Karakulship production and Deserts ecology, Central Asian Scientific Research for Irrigation (SANIIRI). Total 38 participants attended the Farmer Seminar. 11 types of information booklets and brochures related to informing on SLMR project activities and introducing of new technologies were disseminated among farmers and 5 posters were developed and presented. Information on SLMR project activities and new technologies were printed in newspapers and broadcasted through radio channels.

1104. On 14.10.2008 and 07.03.2009 Farmer Field days were conducted in “Sherzod Samandar Birligi” farm in the Syr-Darya province, where water-saving irrigation technologies, new advanced soil leaching technologies, technology of laser leveling and raised bed planting using Dasmesh planter, determination of the soil and water salinity using express methods (EM-38, Ex-Express T, Progress 1T), soil moisture measurements using Diviner 2000 and tenziometers were demonstrated to farmers.

1105. Farmers, heads of water use associations, heads of local authorities, representatives of the District and Provincial Water and Agriculture Management organizations, representatives of regional and provincial Governors, representatives of the Ministry of Agriculture and Water management and mass media participated in this event. The technologies presented during field day were shown on regional TV, was broadcasted via radio, and there were papers printed in

provincial and regional newspapers “Pravda Vostoka” №178 (2372) from 16.09.08 titled as "the Laser beam in a small-scale farmers and other technologies “ with plus ” (Figure 162).



Figure 162. Dissemination

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7 Common technical program: Activity 8. Developing new methodologies using the Greenseeker

The full report is presented in the Final Report - Part I.

8 Socio-economic analysis of policy, livelihoods and SLM options and their effect on land degradation

8.1 Review of literature on drivers of land degradation and their systemic interactions

The full report is presented in the Final Report - Part III.

8.2 Livelihoods analysis at the benchmark sites: Survey results

The full report is presented in the Final Report - Part I.